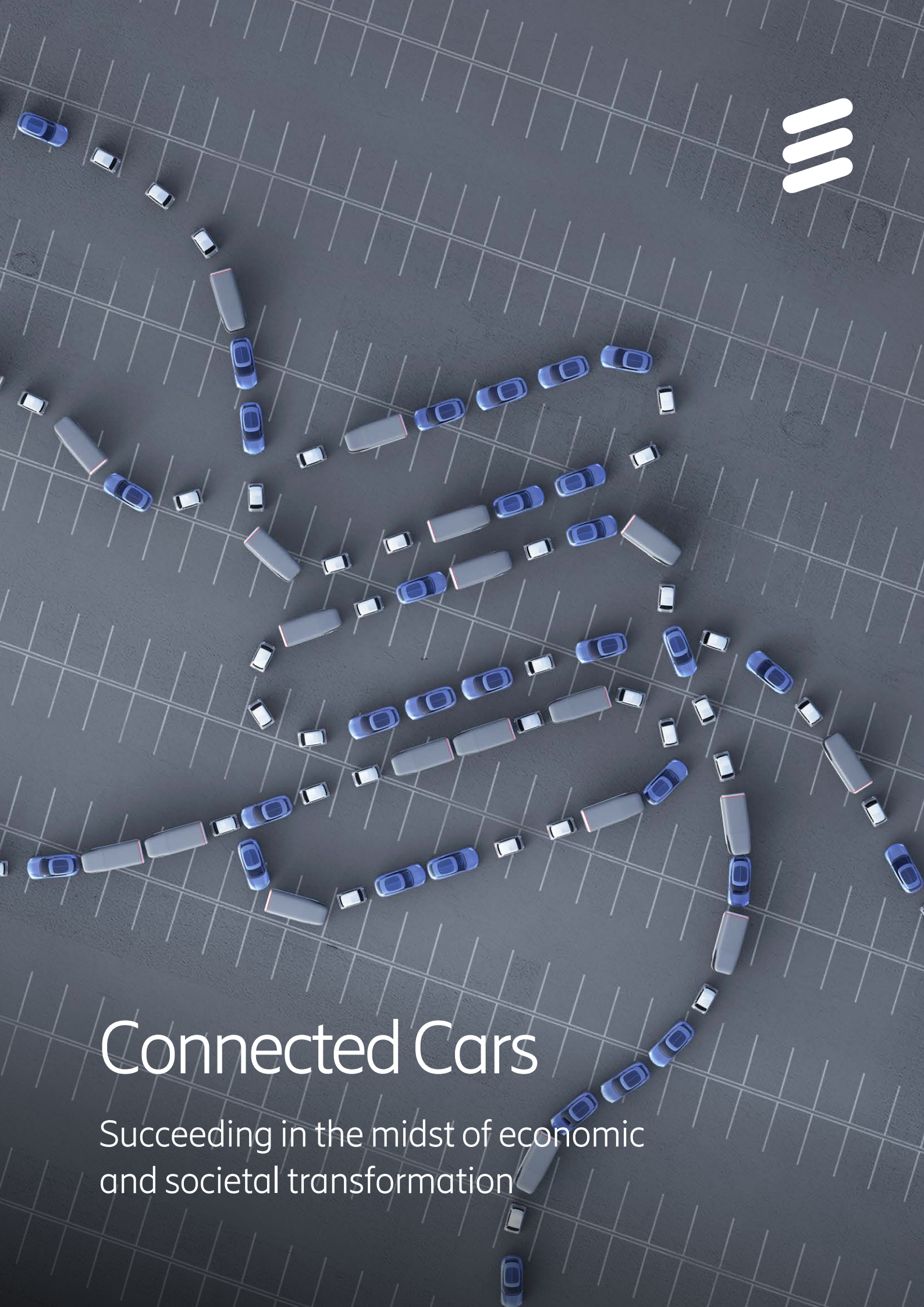


Connected Cars

Succeeding in the midst of economic and societal transformation

A connected revolution on the roads

To say that connected cars will disrupt the current automotive market is to understate the situation. Connected cars will drive the transformation of global wireless data networks, making it unnecessary for many of us to own a car at all. It will also radically alter global transportation. Naturally, with connected cars changing so much of society at large, business models, revenue sources and ecosystems will also change.

The connected car market is forecast to reach $166 billion by 2025 (1), and some sources suggest it may surpass $200 billion. Whatever the size of the connected car market, it will utterly transform the automotive industry, and automakers — also referred to in this report as original equipment manufacturers (OEMs) — will need to adapt in order to succeed in this radically new world of transportation.

Ericsson partnered with Arthur D. Little to identify use cases with significant revenue potential over the next five years. In this report, we aim to help inform current players in the automotive market as they develop business strategies and models for this enormous, rapidly changing market.

"Connected cars will drive the transformation of global wireless data networks, radically altering global transportation, as well as business models, revenue sources and ecosystems."

Contents

IoT and cars – driving change

A brave new world of smarter, safer driving

Our individual experience of travel is set to change radically, along with the automotive industry itself. There are many drivers propelling the industry towards connected cars, but the primary focus is:

Consumer safety/premium
Connected cars are expected to be far safer than today's cars and, according to a survey that PwC conducted in the US, Germany and China, safety and navigation features are the most compelling connected car services driving interest. Studies indicate that connected cars could reduce annual accident fatalities by an astonishing 94% (2). From the customer perspective, improved safety and navigation features are the most important connected car services driving the demand for connected cars, which will later evolve into highly automated driving (HAD) and co-operative vehicles. These new features are set to make them smarter and even safer (3). In fact, customers are willing to pay a premium for increased safety (4).

Regulations
Another important factor driving the high penetration of connected car sales in the EU and US, where it is currently greater than 85% (5) (though these are not higher level applications such as semi-autonomous driving), is regulations. Many governments around the world are actively pushing for the increased adoption of connected car systems. For example, the EU's overarching policy objective is to achieve a cleaner, safer and more efficient transport system across the EU, as set out in the European Commission's Third Mobility Package of May 2018, which includes a strategy to make Europe a world leader in fully automated and connected mobility systems.

Data monetization
This is perhaps the most powerful driver, because as cars gain higher levels of automation and connectivity, they generate more data and that data can be monetized by setting rules for sharing data in a safe, secure and compliant way.

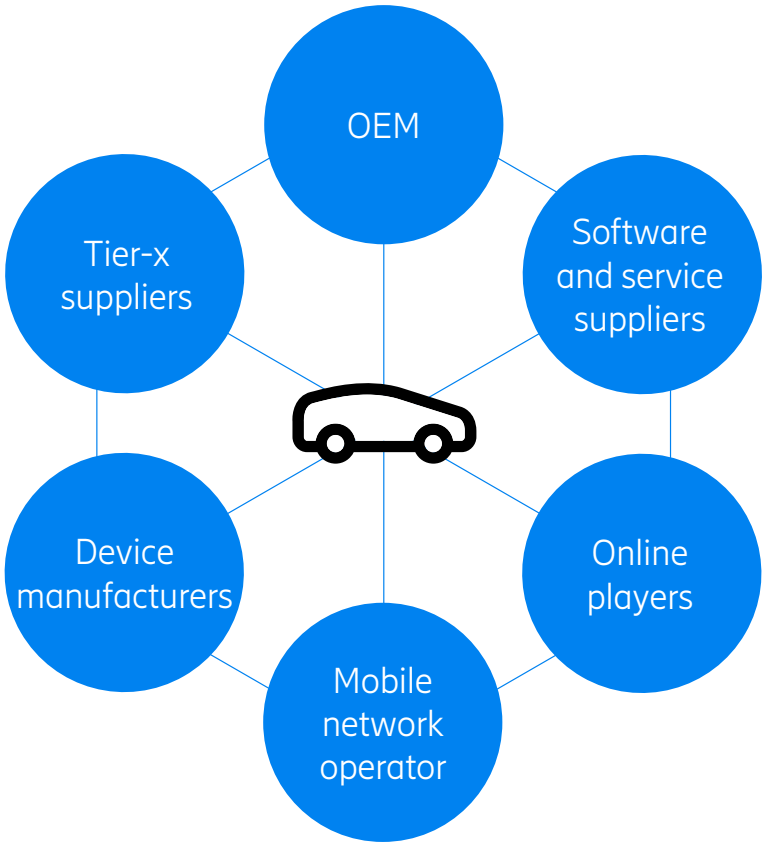
Transforming urban mobility: the accelerating market

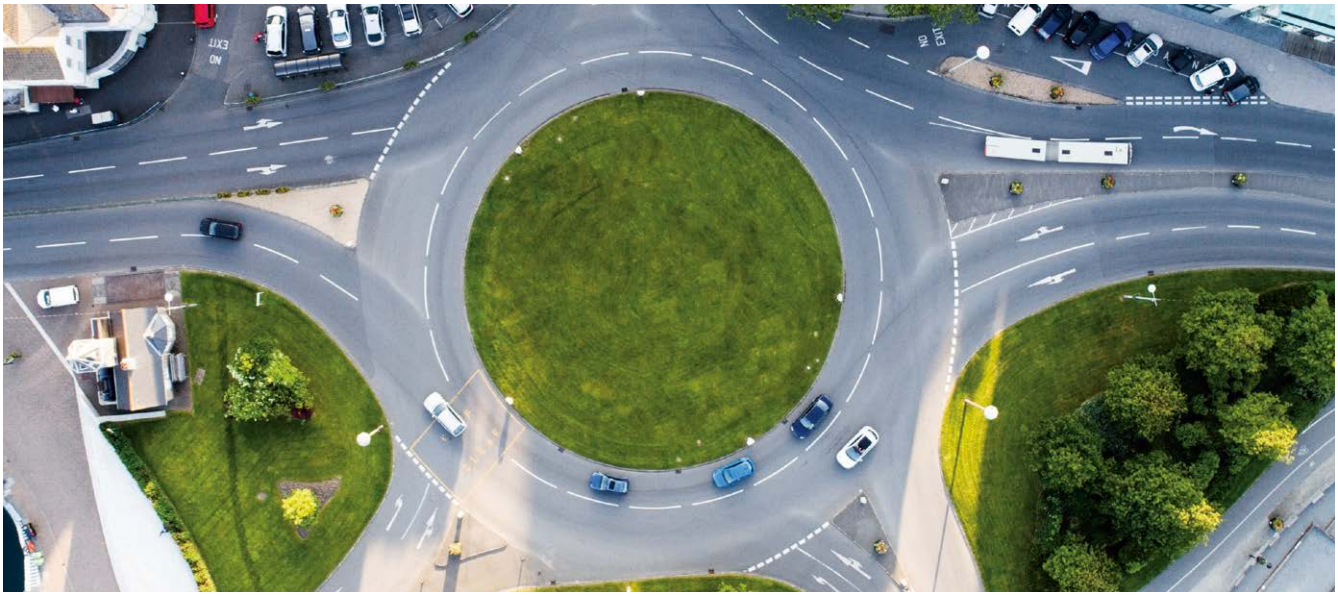
Developing the right business strategies and models for significant revenue potential.

Mobility as a service
Mobility service platforms, car sharing services and other innovative transportation technologies have and will continue to transform urban mobility. By 2025, the mobility services market is expected to exceed $230 billion dollars worldwide, making it an important (7) growth driver for the connected car market.

A new ecosystem mixing multiple industries
The automotive industry has operated on the same business model for more than a century, and this model has been based on producing, selling and servicing vehicles. Connected cars will radically change that model from one in which individual vehicle brands become much less important than the software and services that surround it.

For example, automotive companies face competition from both startups and online players. Smaller, more nimble organizations are succeeding in providing transportation services with new business models, agile processes, rapid releases and a sharp focus on the customer. The emerging automotive industry ecosystem is expected to be a mixture of technical, agile, high performance companies from multiple industries, each of which will bring their own specialization and value to the mix.





To succeed, automakers must reinvent their organizations with digital technologies and consider their position in the ecosystem, so they can expand beyond traditional vehicle sales. In a world centered around mobility services rather than vehicle ownership, the vehicle brand will diminish in importance. After all, how many people select a rideshare based primarily on the brand of car the driver is using? Collaboration with other companies within the ecosystem will become critical to bringing new mobility products and services to market.

This is not news to automakers. Three-quarters of auto executives surveyed by IBM agree that, in order to successfully switch to digital, they will to a large extent need to shift focus towards outsourcing vehicle production operations (8). Cloud computing, AI and IoT were cited as the highest investment areas by OEM executives.

The movement towards connected cars will create a new automotive tech-stack. In-vehicle and roadside technology will capture and process data to understand the environment to plan and actuate vehicle actions. Communication service providers are rolling out 5G at record speed for a new generation of wireless connectivity. The regulatory landscape is slowing the pace somewhat but once it is fully deployed, 5G will enable vehicle-to-anything (V2X) solutions that will communicate with the network and the vehicle's surroundings. Cloud solutions will store and manage the large amounts of data generated and there will be a myriad of opportunities for application services such as product optimization, maintenance, service and end-user services.

5G connectivity as a key enabler and growth driver

Looking at different sub-segments of the connected car market, which do not have clear boundaries as they somewhat overlap, the telematics and advanced driver assistance systems (ADAS) market is expected to see the highest growth margins. Software accounts for a large part of that growth, which will expand its share of the total revenues significantly as cars become connected — about 90% of vehicle innovations are expected to be software related (9).

Additionally, the ADAS segment is expected to grow significantly, reaching $36 billion by 2025 for a CAGR of 30.8% (10), driven mostly by government regulatory authorities and OEMs that have taken strict actions to improve transportation by addressing key challenges like traffic congestion, road accidents and cost of transportation.

Governments have pushed to mandate features like automatic emergency braking and lane departure warning because they reduce accidents. These technologies are based on in-car services, but connectivity can extend them, acting as a contributing sensor to extend line of sight beyond the immediate view of the onboard devices.

For these sub-segments and the market as a whole, 5G connectivity will be a key enabler and growth driver. The global automotive sensor market is expected to grow to $40 billion by 2025 for a CAGR of 10.5% (11). The installation of ADAS in vehicles has taken the application of sensors in vehicles to a new level, but this growth is also driven by the rise in demand for vehicle electrification, formulation of stringent government regulations related to emissions and the increase in consumer demand for safety and comfort in vehicles.

Finally, by 2027, the global market for in-vehicle infotainment and related services is expected to reach around $55 billion, a CAGR of 10.7% (12). An increase in efforts by governments to develop safety and security solutions; growing demand for smartphone features in cars; and additional technological advancements will all boost the in-vehicle infotainment market.

However, a lack of seamless connectivity and the complexity of in-car infotainment devices may limit its growth. For these sub-segments and the market as a whole, 5G connectivity will be a key enabler and growth driver.

Vehicle diagnostics and personalization

Developing the right business strategies and models for significant revenue potential. Projections suggest that this could create value pools worth $450 billion to $750 billion by 2030 (6).

As mentioned earlier, there are huge opportunities to monetize and capture value from the data generated by connected cars. From the industry's point of view, the core value lies in the areas of vehicle diagnostics and maintenance, as well as in-vehicle personalization.

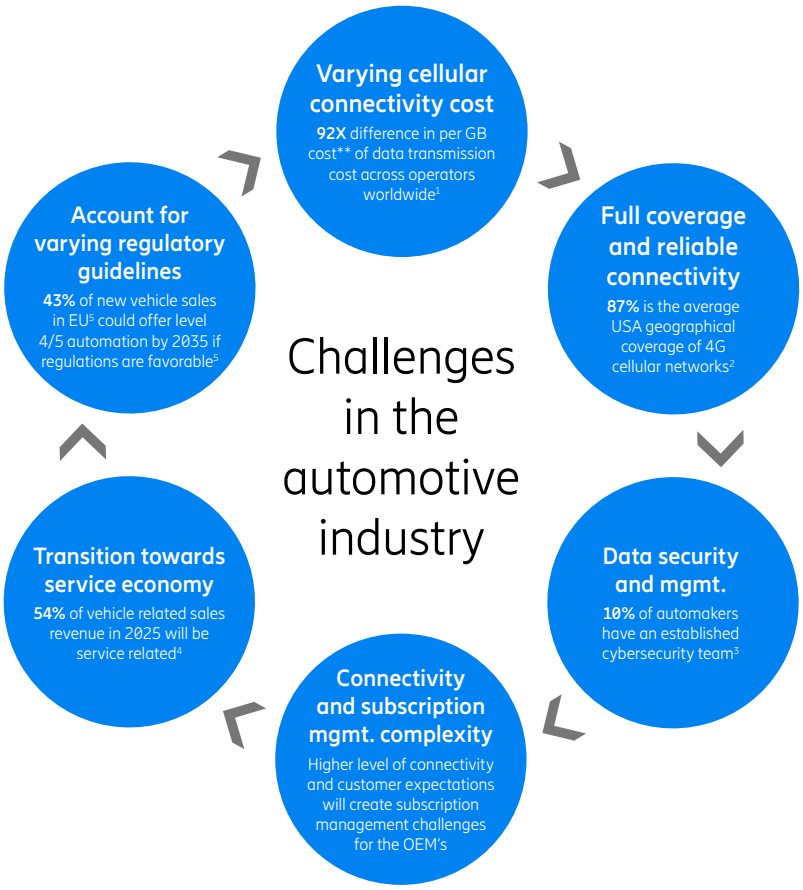
Being able to proactively diagnose and fix issues using insights from data is especially valuable because then the vehicle can handle many maintenance situations on its own. Other consumer experience opportunities such as personalization, AI-based insights about occupants and linkage to lifestyle activities are digital capabilities that can create brand loyalty.

5G communications will primarily enable safety and mission-critical services, but other services will benefit from faster vehicle connectivity, such as high-speed video or gaming applications that demand heavy bandwidth. New mobility and adjacent industry products and services, along with the ability to sell data, can also create new income streams for automotive companies and their business partners.

Looking at the overall use cases for connected cars, ranked by their spending CAGR, vehicle security and traveler information systems are the two top opportunities (13). In 2018, 623 million EUR was spent on vehicle security and 72 million EUR on traveler information systems (14). These use cases are expected to grow the fastest.

In comparison, $2.2 billion was spent on vehicle infotainment, $1.6 billion on automated public transit and $1.1 billion on fleet management. However, these use cases are expected to have a lower CAGR going forward (25%, 11% and 7% respectively) (15).

Car manufacturers face various challenges related to service, data, regulation and cost



Source: 1. Cisco. **2**. Rethinkresearch. **3.** AT&T. **4.** Counterpointresearch. **5.** Deloitte; Arthur D. Little; Ericsson. * Survey conducted by Deloitte in 2020, with sample size of 1,279. ** Based on report conducted by Cisco comparing projected per GB costs 2023 of Jio (0,009€) and Proximus (0,89€), C-ITS: cooperative intelligent transport system.

The cost of success

Although there is a significant opportunity for OEMs to capture value, they will face a number of challenges if they pursue them.

Connectivity costs
First, there is the challenge of varying cellular connectivity costs. As data volumes increase, the costs associated with transmission become increasingly important, requiring vehicle manufacturers to determine who values the data and what the value of the data is. The cost can also vary significantly between different countries, exemplified with two extremes, where prices could be 92 times higher in India than in Belgium (16).

The cost of cellular connectivity may drive manufacturers to make a series of decisions:

- Is the data valuable to the manufacturer? If not, potentially discard.
- Is the data required while the vehicle is in motion? If so, use cellular.
- Can the data be obtained while the vehicle is stationary or is the data's value time-sensitive? Choose the most cost-effective path, given the available networks and the amount of data to transmit. This may not be exclusively cellular; it may be WiFi or Ethernet. In some cases, the best option may be to store the data locally for collection by a technician.

As connected vehicles become increasingly prevalent and the dutycycle data volumes increase, cellular network operators and vehicle manufacturers will have to determine how to support cost-effective deployments at a global scale.

Reliable coverage
It is also currently challenging to ensure the full coverage and reliable connectivity that connected cars and autonomous driving require. Currently cellular coverage is still patchy, and areas with weak or zero coverage are not entirely confined to remote rural areas. In the US, the average coverage from the major cellular carriers is 87% of the country (17). It's important to note that coverage does not equal service, as the signal can be so weak that critical applications may fail.

Cybersecurity
Alarmingly, cybersecurity is still unstandardized in the automotive industry. According to a report from the Ponemon Institute, software security is moving at a much slower pace than technology in the industry, with only 10% of automakers having an established cybersecurity team (18). OEMs must commit to security testing as an investment that will result in better quality vehicles, not as an expense with no direct payback.

> " As data volumes increase, the costs associated with transmission become increasingly important, requiring vehicle manufacturers to determine who values the data and what the value of the data is."

OEMs also need to prioritize consumer privacy and security, as software vulnerabilities could undermine the safety of connected car systems and features and put both the user's sensitive information and physical safety at risk. OEMs and the entire supporting ecosystem must adopt a cybersecurity culture that not only addresses the obvious exposures in the vehicle's software, but also other hidden vulnerabilities that could arise from third-party components.

Connectivity and subscription complexity
OEMs will face connectivity and subscription management complexity. The efforts and resources required to manage connectivity and subscription will increase significantly as more cars become connected. This can present complex and costly challenges for the OEMs in terms of providing sufficient support, operational monitoring and performance management.

The amount of data consumed will increase exponentially. However, if all data is treated equally and billed to one subscriber, who pays? It's a big question. Will car owners pay for general software updates driven by the OEM? Are OEMs willing to pay for entertainment-based data usage consumed by passengers?

OEMs and their partners will need to wrestle with these questions and come up with a model that the market will bear.

The transition towards service economy
Services will expand its share of revenue significantly over the next few years, and is expected to account for more than half (54%) of connected car revenues by 2025, (19) which will require OEMs to adapt their organizations and business. Digital features in cars today can be expensive and complex. OEMs will need to step up their game to provide in-car experiences that are as seamless and intuitive as smartphones. Those that fail to innovate and bring costs down through scale risk losing the race, leaving significant revenue on the table.

Varying regulatory guidelines
Regulatory guidelines are necessary to enable the roll-out and adoption of connected, highly automated vehicles. Unharmonized regulatory guidelines present serious challenges as drivers attempt to cross borders, and the stakes are high. If the regulatory environment in the EU is favorable, for instance, 43% of vehicles there could be partly or fully autonomous by 2035 (20).

The path forward for OEMs

Connected cars – the most sophisticated smart devices available
OEMs must think strategically about the future of their business. In a study performed by IBM, 69% of automotive executives say the brand is a competitive advantage, but only 46% expect this to be the case by 2030 (21). Brand alone will not be sufficient to retain the customer control that automakers currently enjoy. To retain it, they must successfully integrate the customer's connected lifestyle with existing mobility solutions.

OEMs have a great opportunity to create in-vehicle digital experiences that can attract consumers to their brands by integrating with other personal devices to configure and connect into other aspects of a person's life. With the ability to learn from and personalize occupants' preferences, vehicles could potentially become the most sophisticated smart devices available to consumers. Enabling customers to focus on what activities they want to pursue while they are inside their vehicle, transforms travel time from "time wasted" to "time well spent."

OEMs also need to make critical decisions on which skills to keep inhouse and which should be outsourced to partners when developing attractive value propositions and the best go-to market strategies. They must clearly understand what's strategically core to the business and what's open for collaboration, the overall goal being to deliver value through platform-derived ecosystems. OEMs should also leverage their deep expertise, open workflows and data to seize the expansion potential within the ecosystem. Further, it is important to create an ecosystem structure where new players can easily and quickly engage to focus on value creation.

The collection and analysis of data will also be integral to OEMs' success. For OEMs, data insights can help transform the customer experience and create new services. Data is everywhere and OEMs should be ready to capture new data sources from all facets of the business, including the vehicles, mobility services and customers to gain new insights and opportunities in R&D or for optimized and customized marketing. AI technologies will curate and enrich data to meet specific business needs. The OEM must also share data and insights within the enterprise and across the ecosystem to co-create new business models and revenue streams.

" With the ability to learn from and personalize occupants' preferences, vehicles could potentially become the most sophisticated smart devices available to consumers."

Security and privacy must also take high priority, in order to build customer confidence and that all important competitive factor. For highly automated vehicles, it is critical that the growing volumes of data transmitted to, from and within the vehicle are secure. The vehicle will rely on data provided by trusted sources to make quick, accurate decisions — and to prevent, identify and isolate malicious threats.

These requirements underscore the need to move the automobile's computer architecture from a decentralized approach with numerous discrete technologies, to one that relies on a more homogeneous system for simpler management. The automotive industry's ability to respond to these requirements will help determine how quickly technological advancements can be rolled out to consumers. Technology companies with established track records of addressing these challenges are critical partners in helping to enable auto industry success.

The digital disruption of the industry will enable new business model approaches and have implications on the OEMs' operating model. The value of a car will undergo a shift, which will add to the pressure on OEMs. Today, the value for an average car is 90% hardware and 10% software (22). In the future, hardware's share lowers to 40% and the value instead moves to the software (40%) and content (20%), including the apps that bridge and integrate the hardware and software (23).

" The digital disruption of the industry will enable new business model approaches and have implications on the OEMs' operating model."

Business models for a new connected automotive industry

The connected and highly automated car will enable new business model approaches, the most prominent of which will be mobility services. The IBM survey of automotive executives mentioned earlier found that 84% of current revenues comes from traditional sales, 5% from mobility services and 11% from other services. By 2030, they expect revenues from traditional sales to drop to 78%, mobility services to double to 10% and other services to remain at about 12% (24). For a company with total revenues of $100 billion, this would be a $5 billion increase for mobility services, not taking into account overall revenue growth between 2019 and 2030.

Just under half (48%) of the executives surveyed said their organizations already generate income from mobility services today. Based on their expectations, 80% of OEMs will do so by 2030 (25). Concepts that could be exploited include ridesharing, fleet sales and management and time splitting.

Another potential model is the data driven business. OEMs already sit on valuable data and as automation and connectivity increases, the amount of data generated by their business, products, services, customers and other external sources will grow exponentially and become even more valuable. One recent prediction is that up to 73% of data possessed by an OEM will go unused for analytics (26).

There is huge potential in leveraging this data to improve industry and company practices, the driver's in-vehicle experiences or creating new mobility options such as:

- New experiences: Creating personalized touchpoints with consumers.
- New expertise: Developing opportunities with other industries.
- New focus: Defining and testing new business model ideas.
- New ways to work: Enabling a responsive organization.

A significant majority of OEM executives believe that incorporating new operating models and novel ways of working will contribute to the success of their companies. Reinventing the digital automotive OEMs organization will require new skills, not just skills that help workers do things faster. These new skills enable the workforce to perform the digital tasks that can support — and create — new ways to work.

Supply chains will also be significantly transformed by the use of digital technologies such as sensors, IoT and AI. Just as cars are changing, so too must the supply chain upon which automakers rely to source, build, deliver and service vehicles. Collaboration will be more critical than ever. To meet these new demands, many automakers are already working with new partners, as well as engaging with current partners in new ways.

As the supply chain evolves, those who lead the charge and collaborate with the leading technology companies will be in the best position to compete and succeed.

As organizations increase automation, they will gain additional capabilities to obtain actionable insights into the movement and condition of materials and goods throughout the supply chain, which can enable companies to proactively predict and respond to issues, instead of reacting after the event.

Value of Use Cases

For the analysis, we have used a baseline OEM, which is an average of the top five global OEM/vehicle manufacturers, to deploy the two use cases of smart over-the-air updates and connectivity & subscription management. The yearly revenues, on average, of the top five OEM accounts are $208 billion and the connected vehicle fleet size by 2025 is estimated to be $10 million (27).

The proof is on the road

Smart Over-the-Air (OTA) Updates

Use case 1:

Vehicles are increasingly reliant on software, a trend that will only accelerate as the industry moves closer to autonomous driving. A modern connected car includes about 100 million lines of code and the need for software fixes, upgrades and maintenance will increase. Already in 2018, nearly one in five cars in the US had an open recall, and 19% of those had to be recalled due to software defects (28), affecting 18 million vehicles. Warranty and recall campaign cost for OEMs and their suppliers are high, accounting for $22 billion in 2016, a 26% increase from the previous year (29).

Over-the-air updates (OTA) require cellular connectivity, and given the size of some updates, 5G will make the process far faster and more efficient. OTA can enable OEMs to fix, maintain and improve vehicle software remotely by downloading code to the vehicle from a cloud-server (30).

OEMs only need to update the part of the software that requires fixing, saving on download time and distribution costs (31). Not having to physically perform updates for software-related issues saves an enormous amount of money on warranty and recall costs.

Also, OTA updates provide an easy and fast means of regularly distributing feature improvements and performance enhancements (such as improving the range of an electric vehicle) over the product's lifetime. By 2025, 50% of vehicle value will be generated through software (32).

OTA can support additional revenues for OEMs by offering features as "in-app purchases." Automakers such as Tesla and BMW are already offering these (33). Smart OTA can also enable OEMs to use analytics to further improve vehicle design and engineering.

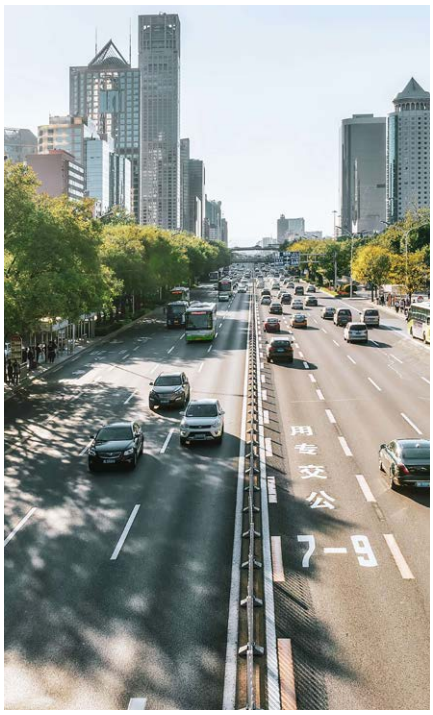
Additionally, analytics can be employed to determine the right point in time and the proper location to perform a vehicle update, maximizing cost savings on data transmission as well as driver safety.

Financial benefit of OTA
The financial benefit of OTA reaches around $98 per connected vehicle as annual cost savings by year 5. This saving comes from two primary areas:

- **Cost savings from OTA updates (accounting for 87%):** These cost savings are realized thanks to enablement of remote software updates, which would otherwise require a physical visit to the OEM dealership. Software related recalls make up a significant share of overall vehicle recalls (34).

- **Cost savings from smart data transfer (accounting for 13%):** Smart data transfer cost savings are realized by scheduling data transfer during periods of low data usage and demand. During those periods, OEMs can take advantage of discounts. This is also an opportunity for Communication Service Providers (CSPs), as they can can steer traffic and avoid congestion by offering discounts during off-peak hours. If automakers utilize exposed network functions, then data rates can be dynamic.

Generally, the use case delivers a year-on-year value growth rate of 25% over the next five years, with $435 million in total cost savings by year five, of which cost savings from OTA updates make up the larger share. The share of cost savings from smart data transfers is expected to increase from 1% to 19% as data transfer volume rises.



Connectivity and Subscription Management

Use case 2:

The amount of data traffic related to connected vehicles will increase exponentially over the coming years, as the numbers and capabilities increase. An autonomous vehicle under task, for example, is generating 5 TB of data each hour, sending and receiving data for computer vision using video cameras, radar and laser light detection data via sensors. However, only about 30% of this data needs to be uploaded. For autonomous cars, data transfer requirements are estimated to be between 383 GB to 5.17 TB per hour (35).

In addition to exponentially growing connectivity requirements, vehicle users also expect high performing and seamless connectivity independent of their location, whether they're driving around their neighborhood or in a foreign country (36). In fact, more than 25% of car buyers indicate that they prioritize connectivity over other features such as engine power or fuel efficiency (37).

It's cumbersome and expensive to provide the flexibility required for this kind of ubiquitous connectivity with fixed SIM cards, because they need to be changed physically.

This incurs significant costs for the OEM whenever a customer needs to switch operators to provide the required or expected connectivity to vehicle users (38). In fact, the cost to the OEM for inserting a fixed SIM is ten times higher than the cost of updating an eSIM. This is because a SIM card holder needs to be built into a not-readily accessible area in the car and a production SIM needs to be inserted for testing purposes. As the car is delivered to the vehicle user, a SIM with the correct profile (depending on location) needs to be manually inserted and tested by the dealer. The cost for eSIM is around $21, whereas fixed SIM accounts for around $210 (39).

OEMs currently deliver cars to about 170 different countries, so they need to be able to support a large number of CSPs. Fixed SIM cards increase complexity with regard to the management of operator relationships, and they create lock-in effects (40). In some countries — such as Russia, India, China, Brazil, Turkey and the UAE — roaming over extended periods of time and in some cases for any amount of time, is prohibited, which requires OEMs to establish contracts with local operators.

An eSIM can support at least 10 different CSP profiles which can be flexible and remotely switched (41), enabling OEMs to deliver their vehicles to any country with whom they have a provider contract. The OEM buys the eSIM from a specific CSP and contracts for remote subscription management on the eSIM. The CSP then creates a profile and downloads it to the eSIM to enable connectivity and manage it during the duration of the connectivity contract. If the OEM wants to change the contract to another CSP, then the other CSP can download the profile and manage connectivity.

The CSP can be part of a larger alliance of operators, which provide and manage local connectivity over large regions (42). With a single, unified connectivity solution, OEMs gain one contract, one integration point and one service level for all markets. As a result, OEMs can buy services from one CSP within the community of CSPs and then manage the subscription from a single point, which eliminates complexity and reduces management costs.

To provision eSIMs for different countries remotely or over the air, OEMs can use a connectivity and subscription management platform. It is essential that systems of different operators are interoperable and that they all provide simple and flexible management and orchestration to OEMs (43).

Connectivity and Subscription Management

Use case 2:

Financial Benefit of Connectivity and Subscription Management
The financial benefit reaches around $11 per connected vehicle as annual cost savings by year 5. Two primary benefits account for the value:

- **Reduced OEM manufacturing/ installation costs using eSIM (accounting for 21%):** The cost for installing an eSIM into the vehicle is around ten times lower than it is for a fixed SIM, due to the cost of manufacturing the internal fixed SIM card holder, shipping the fixed SIM with the correct profile, and labor costs for installation and testing (44).

- **Reduced OEM connectivity contract change costs using eSIM (accounting for 79%):** A typical CSP contract length runs three to four years. With an eSIM, OEMs can update contracts easily through an OTA or remote download, without incurring the costs of manually changing it out.

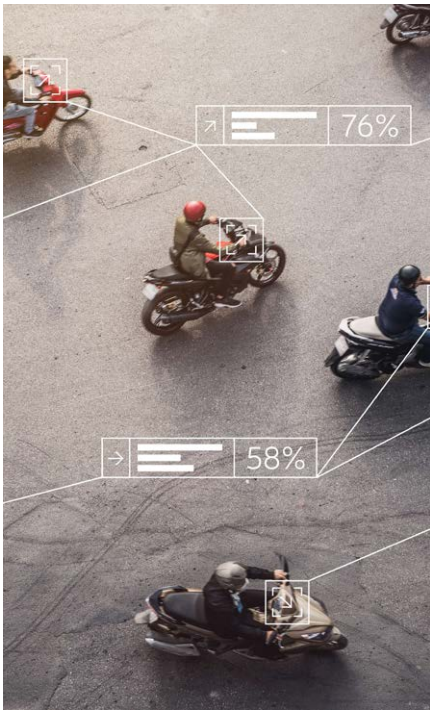
The use cases also provide two other benefits. Roaming charges will be reduced in certain regions, such as Russia and China, where there are strict regulations regarding use of foreign SIM cards locally. eSIMs can potentially address some of those connectivity-related issues, because they enable the vehicle to support connectivity profiles from multiple CSPs, and these profiles can be flexibly and remotely switched (45, 46).

If OEMs contract with a larger alliance of operators through a single contract, they will enjoy reduced costs, thanks to streamlined connectivity management. This is because a single contract facilitates the management of multiple CSP relationships across different regions. Finally, the use case avoids lock-in effects in OEM and CSP relationships and consumes fewer resources during SIM manufacturing and installation.

Generally, the use case delivers a year-on-year value growth rate of 68% over the next five years with a total value of $90 million in savings by year five, through reduced eSIM installation and connectivity cost control.

The use case value for smart OTA updates accounts for 83% of the total savings and the connectivity & subscription management use case accounts for 17%.

Note that, while smart OTA updates make up for the larger share-of-value within the total, the share-of-value of connectivity and subscription management in total value is expected to triple in the next five years. Also, when looking at the global value potential with this reasoning, the global yearly value in year five from the use cases would be approximately $4.1 billion.



When implemented together, the smart OTA and connectivity & subscription management cases produce a yearly steady state net value in year five of about $525 million, representing 0.3% of revenues in year five and a year-on-year value growth rate of around 30%.

Highly Automated Driving

Use case 3:

The ultimate goal of connected cars is to provide fully autonomous vehicles, but there are many steps along the way.

Cars with level 1 automation have been available for several years, and are better known to the public as having "driver assistance." This includes features such as parking assistance, adaptive cruise control and lane-keeping assistance.

Currently, cars with level 2 automation are available to the public. They provide traffic-aware cruise control and autosteer with lane change, which enables automatic steering on undivided roads but with speed limitations. Level 3 vehicles are available to a limited extent. In Level 3 automation, the autonomous car's driving system performs all the dynamic driving tasks with the expectation that the human driver will respond appropriately to a request to intervene.

Level 4 and 5 will require more than just technology upgrades such as 5G connectivity, however. These vehicles will be heavily regulated, and the process of hammering out these regulations and complying with them will be slow and complex.

For the most part, we are still in a world of semi-autonomous cars, where human drivers must constantly monitor the driving environment. 5G will be a key enabling technology in making the dream of further automation possible. It provides the ability to:

- Boost capacity to multi-gigabit mobile broadband.
- Unleash new spectrum bands, leveraging carrier aggregation and advanced antenna systems.
- Enable low-latency, time-critical communications.
- Deliver data within a specified time window with desired guarantee, e.g., less than 50ms latency with 99.999% reliability.
- Enable high density of connected vehicles.
- Support a high number of communication devices, both in uplink and in downlink.

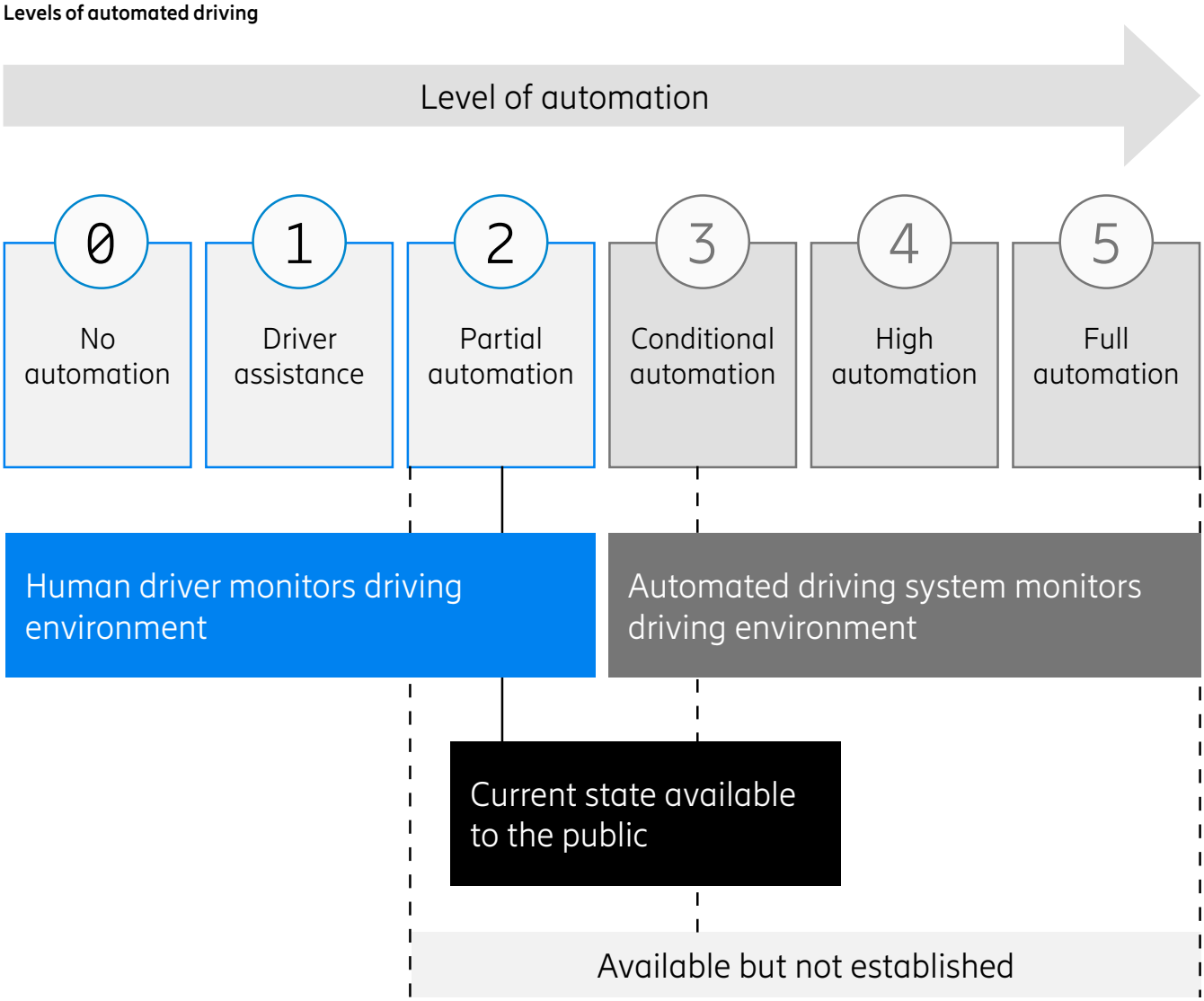
Connectivity can extend vision for a car beyond the driver's line of sight and enable cooperative functions, but this ability requires high definition (HD) mapping and precise sensors with cellular connectivity.

For safety, it's critical to have accurate maps every time and everywhere. HD maps must be always available with the latest updates streamed to the car, a function which demands reliable, seamless connectivity. Sensors require high bandwidth and occasionally low latency as well, so driving adjustments or deviations from deltas can be sent. These technologies also require the enormous throughput, high bandwidth and low latency of 5G.

Highly Automated Driving

Use case 3:

Levels of automated driving



The new automotive business landscape

The advent of highly automated vehicles will substantially change how the automotive marketplace works, because it will decenter the vehicle from the focal point of the ecosystem. OEMs and distributor partners are being joined by new and emerging players of different sectors and will play a role in shaping the new, highly automated vehicle market. Companies can also leverage the opportunity to expand into other ecosystem roles. For instance, OEMs, technology firms and suppliers can all become software and service providers so long as they recognize the opportunity and make an early move to capitalize on it.

Some examples of how key players in the ecosystem can capture value in the transition to higher degrees of automation and connectivity include the following.

OEMs will have the opportunity to capture value through the traditional model of selling vehicles; however, aspects such as fleet sales might create new opportunities. In addition, there will be the ability to capture value through services related to automated driving, tele-operated driving and automated valet parking. Many OEMs have started actively developing their own software and technical capabilities to compete, rather than cooperate, with other tech companies. OEMs will also have the opportunity to take the important role as a mobility service provider, which will be key to attracting more customers. The higher the automation level vehicles have, the more the OEM can leverage cost-efficiency opportunities such as reducing vehicle service costs.

Software and service providers will be able to capture significant value from higher automation as the demand for software modules and system integration will increase at higher levels of automation. Major tech firms are manufacturing and producing vehicles of their own, initially for a commercial mobility option and later also potentially for personal use. Supporting tech firms will act as technology providers at a supplier level for both software and hardware, through collaborations with the vehicle manufacturers. The type of collaboration that takes place will have a substantial impact on shaping the ecosystem. One tech company might provide the software in exchange for a large payout and share in the business, while another could provide the software for free to OEMs in exchange for access to their vehicle's user data, which they will monetize later in analytics and marketing projects.

In addition, these players can exploit connected car services related to a higher degree of automation in the same way as the OEM can: acting as the mobility service provider to the customer. The client base could also expand for these companies to include governmental and local bodies interested in services and data to improve traffic flow and safety.

Online players will also have the opportunity to capture significant value from a higher degree of automation and connectivity. This will enable the customer to engage in activities that would currently be dangerous while operating a moving vehicle, such as watching a movie, shopping online, work or conducting a teleconference.

They also have a significant opportunity to partner with mobility providers and deliver their services in the form of content and applications to the customers via a bundled package. This would operate on monthly or custom price-plans, similar to those currently offered by telecom and television network companies.

CSPs will capture value from monetizing the provision of 5G connectivity, but they can also gain value from providing edge cloud solutions with execution resources (compute and storage) for applications that require networking close to the vehicles, typically within or at the boundary of operator networks.

In addition, CSPs can bundle connectivity with value-added services such as security, authentication, billing, systems integration and data analytics. However, in the connected vehicle market, specialist technology companies, systems integrators and online players will also be looking to provide many of the services being targeted by CSPs.

The new automotive business landscape

Device manufacturers will mainly capture value from providing the necessary connectivity equipment. Highly automated vehicles require a wide variety of sensors such as LiDARs, RADARs, ultrasonic sensors and image sensors, along with many different subcomponents such as semiconductors, chips, actuators and V2X components.

The after- and servicing markets for these devices also present some interesting opportunities. Many OEMs and technology giants have already started to acquire component companies or are producing their own.

Suppliers will capture value in a similar way as they do today, however as the industry is being disrupted, the players will have an opportunity to expand their capabilities and adjust their role in the ecosystem. Tier-1 suppliers are increasingly collaborating with IT companies and startups specializing in technologies such as AI and software to augment their in-house research and development capabilities.

Keys to success
As vehicles increase their level of automation, OEMs can aim to exploit significant new value pools, but they should keep in mind several key factors that will affect their success.

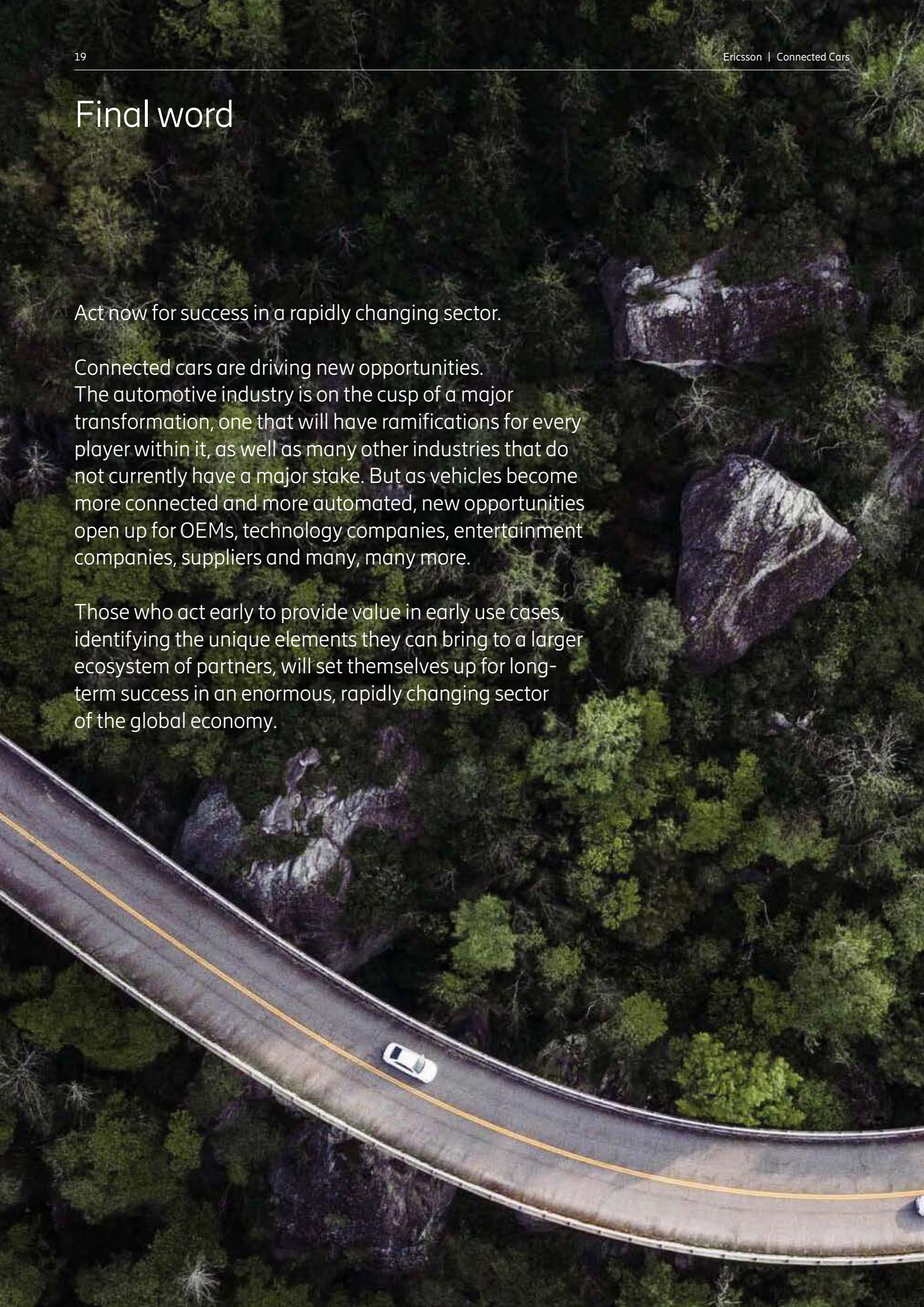
Market share in vehicle sales
It is estimated that the total market size for level 4 and 5 autonomous vehicles will be $60 billion by 2030 (47). Becoming an automation frontrunner will result in significant value capture through the traditional model of selling vehicles.

Mobility services
This is another important value pool, where competition from other players will pose a challenge. For many customers, the traditional ownership model will continue to be a valid option in 2030. But a growing opportunity exists for automotive companies to exploit new routes to growth through mobility services. Revenues from mobility service platforms, shared cars and similar services are estimated to reach $230 billion by 2025 (48) and around 130 million vehicles will be integrated with some type of mobility service by 2030 (49).

Car data monetization
The overall revenue pool from car data monetization at a global scale could add up to between $450 billion and $750 billion by 2030 (50). The opportunity to capture this value depends on the ability to 1) quickly build and test car data-driven products and services focused on appealing customer propositions, and 2) develop new business models built on technological innovation, advanced capabilities and partnerships.

Lowering vehicle service cost
The OEM will also have the opportunity to reduce their costs by as much as 35%, in part because highly automated cars have far fewer mechanical wear-and-tear parts.

Final word



Act now for success in a rapidly changing sector.

Connected cars are driving new opportunities. The automotive industry is on the cusp of a major transformation, one that will have ramifications for every player within it, as well as many other industries that do not currently have a major stake. But as vehicles become more connected and more automated, new opportunities open up for OEMs, technology companies, entertainment companies, suppliers and many, many more.

Those who act early to provide value in early use cases, identifying the unique elements they can bring to a larger ecosystem of partners, will set themselves up for long-term success in an enormous, rapidly changing sector of the global economy.

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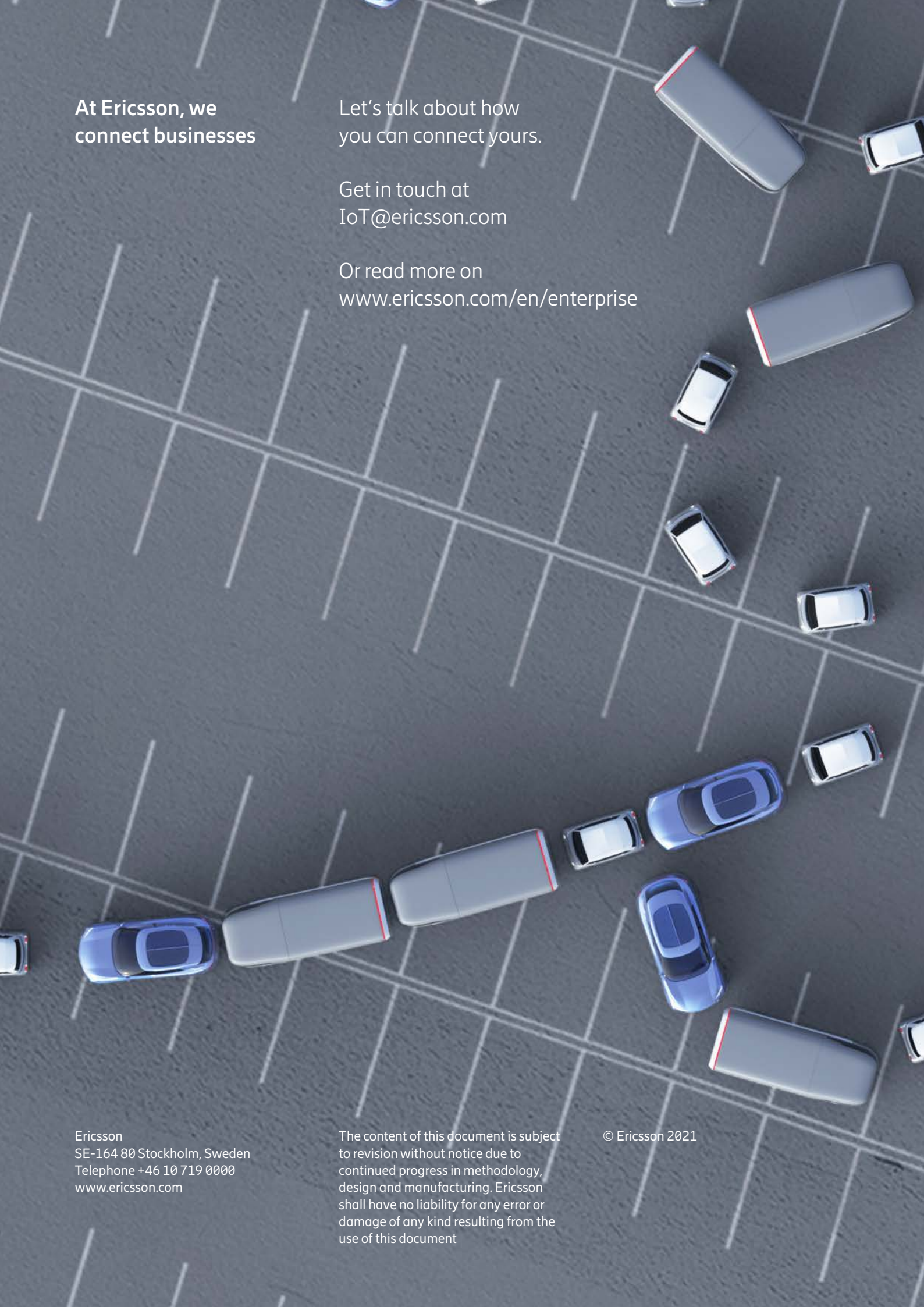

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