



Automotive semiconductors: The new ICE age

**The future of automotive innovation:
moving from the Internal Combustion
Engine to the Internal Computing Engine**

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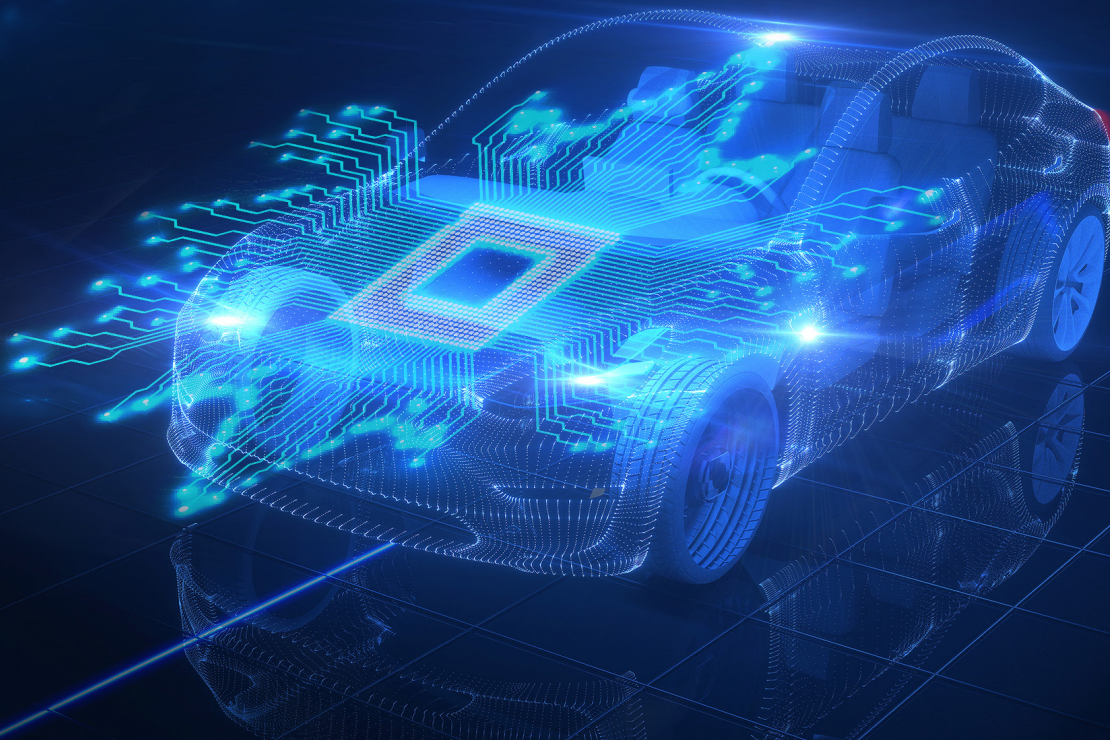
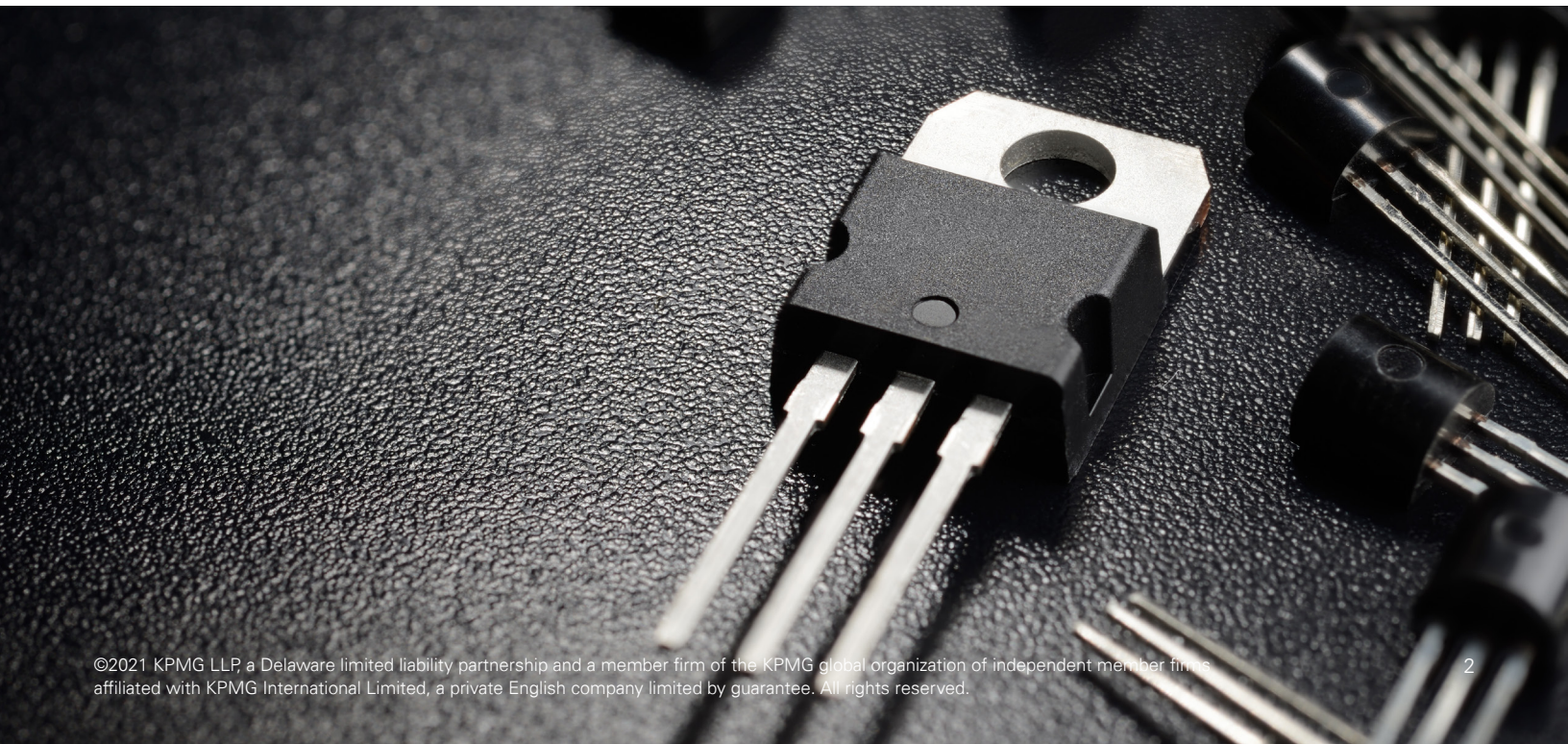
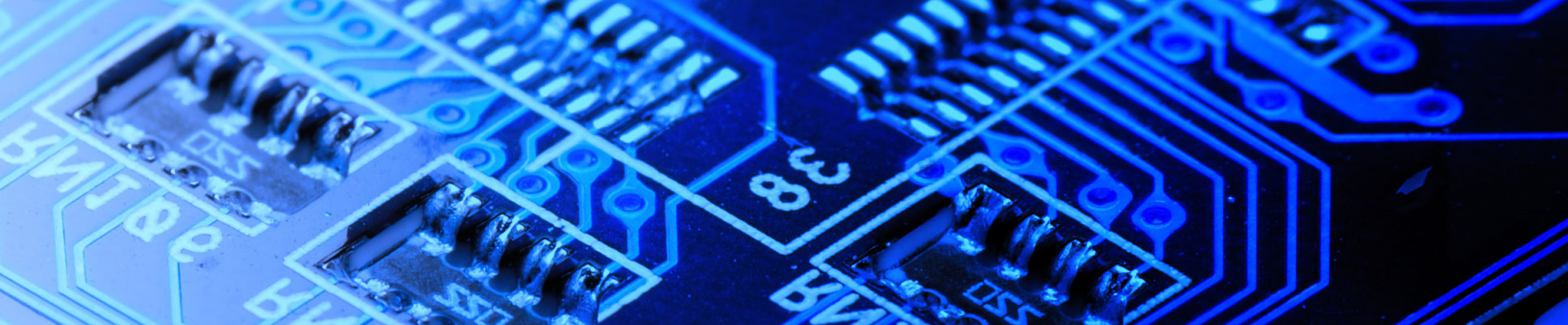


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Letter to the readers

For a century, the internal-combustion engine (ICE) has been the source of value and innovation in the automotive industry. Today, we are entering a new automotive age, when cars will be differentiated by the functionality enabled by semiconductors and electronics. This shift places semiconductors—the building blocks of a car’s “Internal Computing Engine”—at the heart of automotive innovation. That, in turn, is forcing a convergence of the semiconductor, computing, and automotive industries.

KPMG has long been a leader in pointing the way to the automotive future. Our 2012 paper “Self-driving cars: The next revolution” provided an early glimpse of the potential for autonomy. Now, autonomous features are standard on many cars. In this paper, we examine how autonomy, electrification and mobility services are turning cars into supercomputers on wheels. Increasingly, a car’s value will be defined by the safety, convenience, infotainment, and self-driving features provided by all the semiconductors under the hood—and throughout the vehicle. Instead of thinking about horsepower, consumers will be inclined to shop for cars with the best onboard computers and electronic systems.

This shift has profound implications, for both the automotive and semiconductor industries. Even now, automobile manufacturers use semiconductors for everything from engine control to lane-change warning systems, creating a \$40 billion plus market served by more than 100 suppliers. As autonomy and electrification multiply the need for onboard electronics, we estimate that the automotive semiconductor market will quadruple, reaching more than \$200 billion in the next two decades.

The road to \$200 billion will not be a straight line. It will require new kinds of collaboration models between the players across the supply chain—and the integration of

new players, such as software suppliers. Automakers, parts suppliers and semiconductor companies will all face critical strategic and technical choices.

In the following pages, we share our insights about the convergence of the semiconductor and automotive industries—and the challenges involved. If the advanced automobile market evolves like other tech sectors, there could be a lopsided contest for value capture. That could produce a few winners and many losers, as we have seen in personal computers, smartphones and other technology markets.

For now, the future is bright. There are more opportunities than risks. This is the time for companies across the automotive value chain to pick their shots—determining how they can innovate, with whom to collaborate, and where to compete in the new automotive “ICE Age.”



Scott Jones
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Key takeaways

We are on the verge of a new automotive age, where Semiconductors are the key building blocks of the vehicle's new ICE, "Internal Computing Engine"



Four automotive "megatrends"—electrification, autonomy, connectivity, and mobility as a service (MaaS)—are reshaping the industry and dramatically increasing the semiconductor content in vehicles.



Cars are becoming supercomputers on wheels: vehicles will be more and more differentiated by electronics, software-defined features and by the optimal integration of hardware and software across the whole car-to-cloud system.



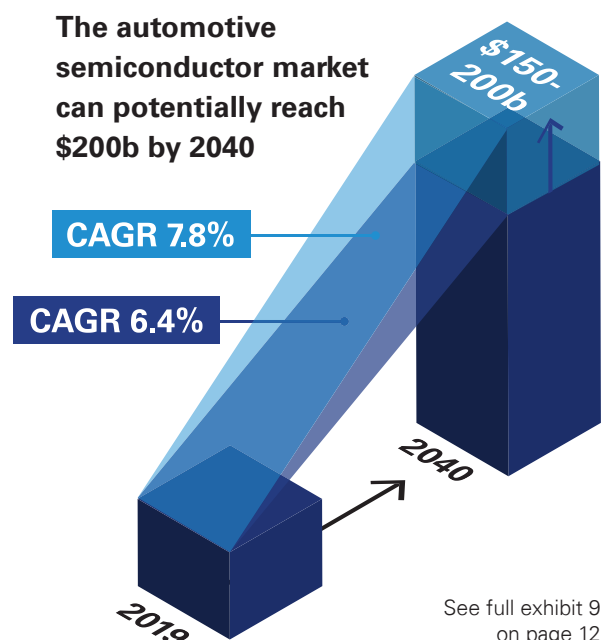
This is a massive opportunity for the automotive semiconductor market: the segment could see strong growth from \$40 billion in 2019 to as much as \$200 billion by 2040—and this value still excludes semiconductors used in automotive-related not-on-board applications like EV chargers or V2X infrastructure.



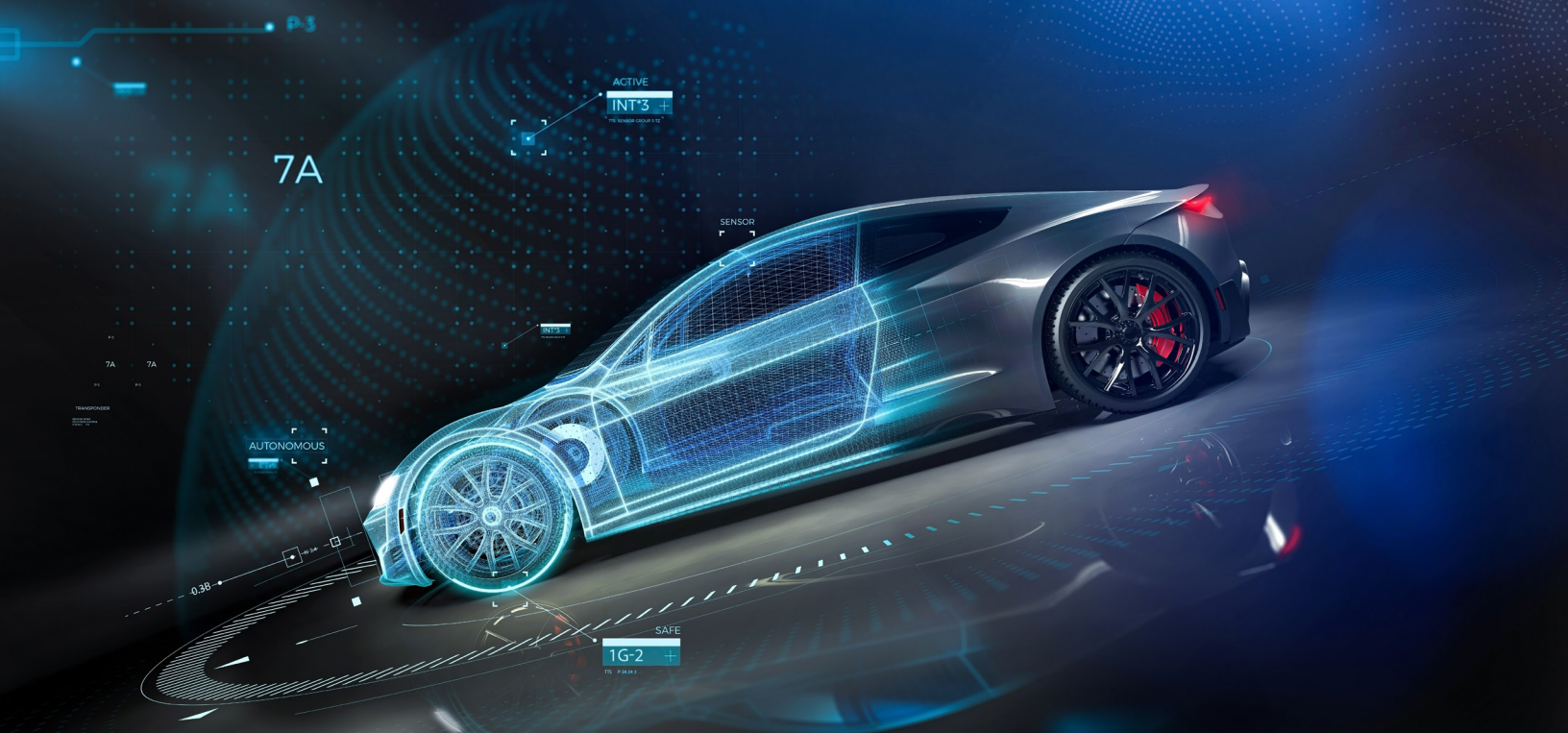
There is potential for further dramatic changes: the automotive industry could follow patterns seen in other technology-driven and software-defined industries, such as personal computers and smartphones, where only few well-positioned players capture value.



Complex decisions await: semiconductor industry leaders and automotive executives across the global automotive supply chain face complex decisions about how to invest (R&D vs. M&A), where to play, and how to attract the talent to win.



See full exhibit 9 on page 12



Introduction: The future

Radical changes are under way in the automotive industry that will have profound impact on how cars will be built and used. The impact will be felt by the automakers and consumers but will be enabled by the semiconductor industry. That's because the four powerful forces reshaping the automotive industry—autonomy, electrification, vehicle connectivity, and mobility as a service (MaaS)—all depend on increasing amounts of data and electronics.

These forces will lead to a sea change in the role and value of electronics in automotive design. And this change, we estimate, could lift the automotive semiconductor market from \$40 billion plus in 2019¹ to between \$150 billion and \$200 billion in the next two decades.

For three decades, automakers have been steadily adding electronics to increase safety, improve comfort, and raise fuel efficiency. Recently, advanced driver-assistance features such as adaptive cruise control or lane departure

warning systems have become standard equipment on many models. Today's nontraditional powertrain designs—hybrid and fully electric vehicles—have twice the semiconductor content (by value) of internal combustion engine (ICE) vehicles.² Tomorrow's fully autonomous vehicles, equipped with LiDAR sensors, image-recognition systems, and 5G communications, will likely have eight to ten times as much semiconductor content as non-autonomous vehicles.

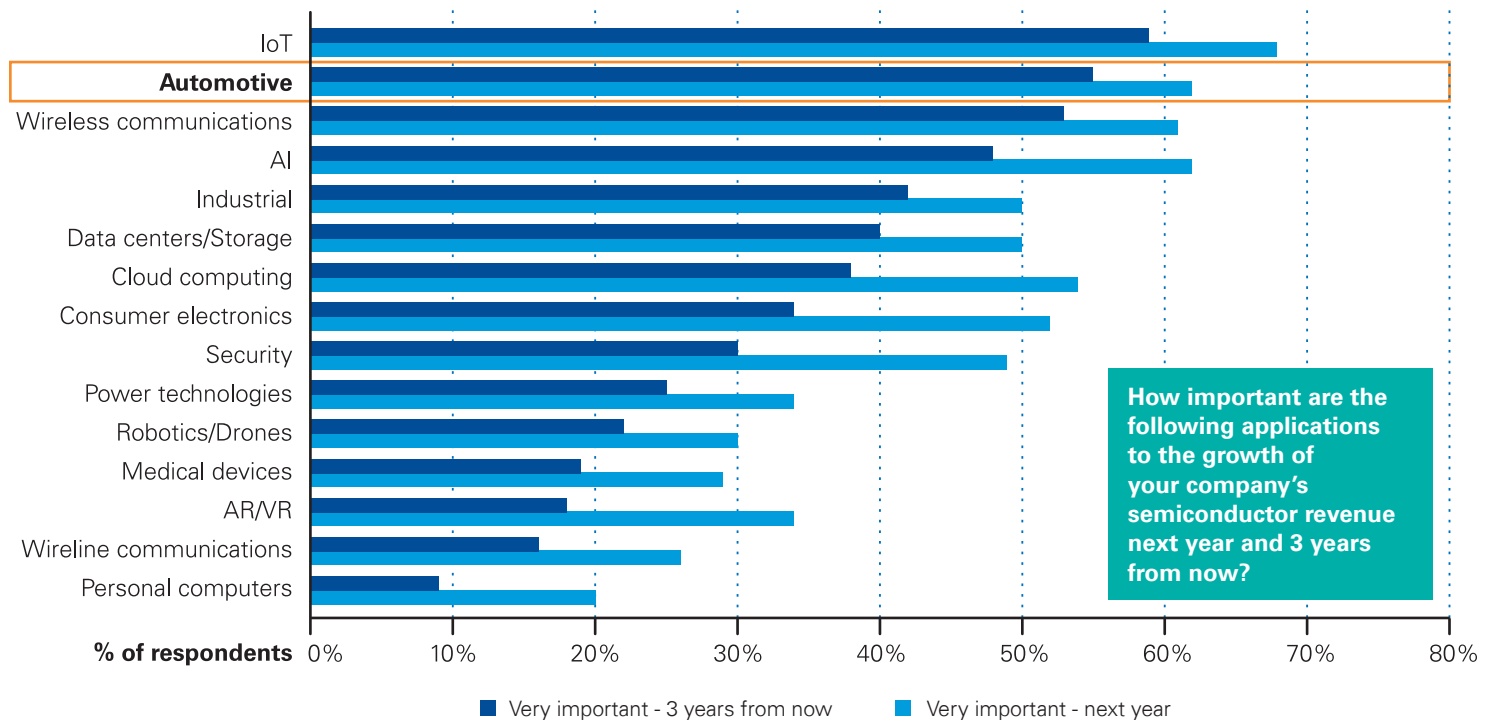
The automotive market is already top-of-mind for semiconductor industry leaders. In the 2019 14th KPMG Global Semiconductor Executive Survey, semiconductor executives said that automotive is the second-most important application for their company's growth in the next few years, right behind Internet of Things (IoT) and ahead of wireless communication applications (Exhibit 1).

¹ Source: Gartner, Inc. Semiconductor Forecast Database, Worldwide, 3Q20 Update

² Source: KPMG insights, originally presented at Semicon West July 2019

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Exhibit 1. Semiconductor executives realize the increasing importance of automotive applications



Source: [KPMG 14th Global Semiconductors Industry Survey, 2019](#)

The prospect of rapid growth and the need for innovation have attracted many new entrants across the whole supply chain. There are new automakers competing directly with traditional automakers, many technology startups (especially in autonomous driving and electric powertrains), established electronics manufacturing services companies (that are in a position to challenge established automotive Tier 1 electronic suppliers for certain systems) and many software suppliers, including some of the top names in the industry.

This means the traditional way of doing business is coming under stress. The long-cemented relationships between automakers, Tier 1 electronics suppliers, and between Tier 1s and semiconductor companies are being transformed. To build the car of the future, market players will need to explore new partnership and collaboration models with traditional players as well as new entrants.

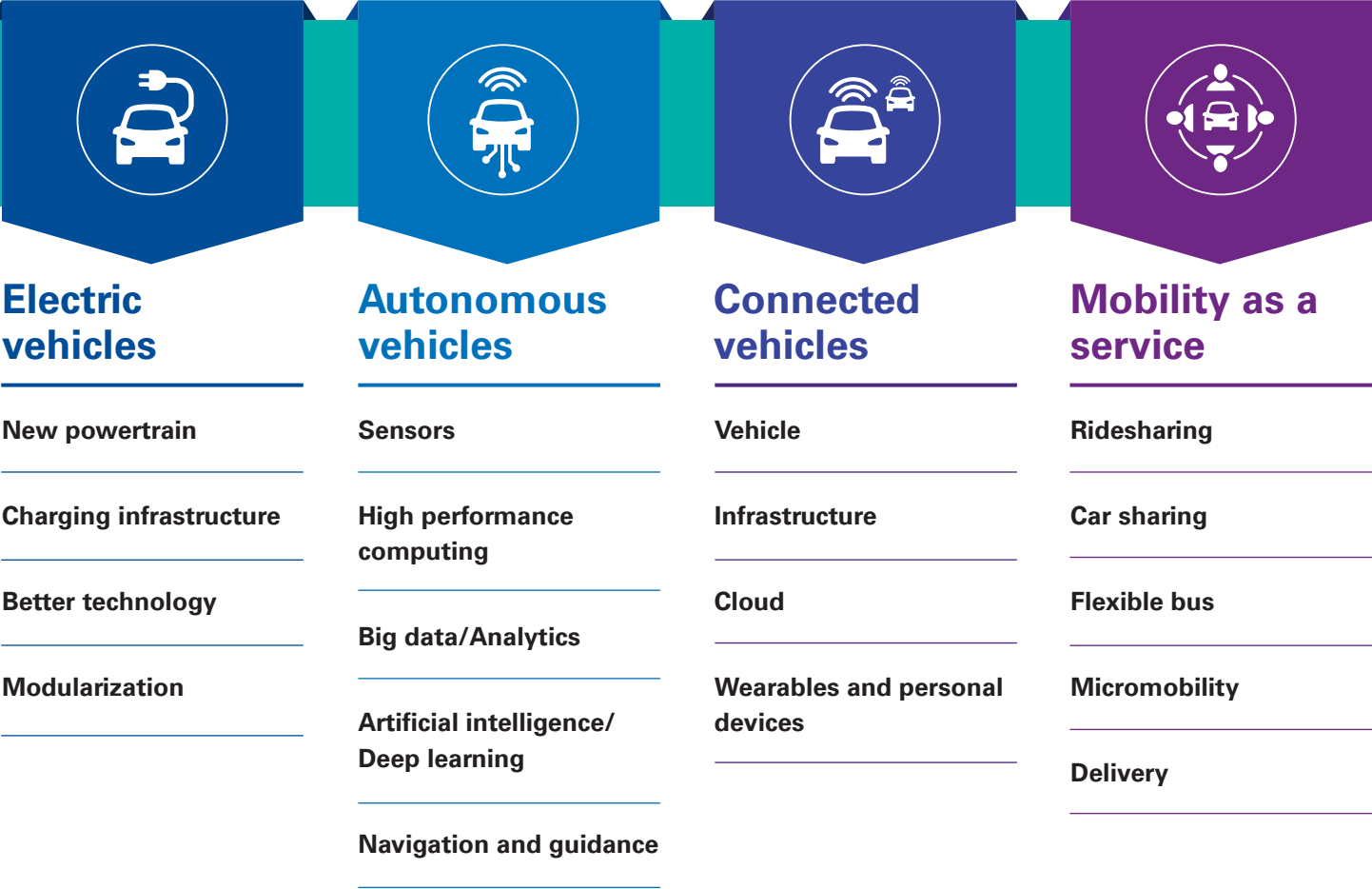
As the market grows, there will be winning and losing positions in terms of value capture. While the automotive business has its own particular characteristics, it will be subject to the same market dynamics as other technology businesses.

From personal computers to smartphones and even data centers, there has been a sharp division between the fate of companies that end up providing or assembling commodity parts versus those that dominate higher-value components (the Intel microprocessor in the PC, for example). There is a similar divide between those that are able to control the user experience and data (like Apple does for mobile, or Google does on the web) and those that do not. Even today, companies are already jockeying for winning positions in markets being reshaped by the four trends we describe in this paper.

Four automotive trends are accelerating semiconductor demand

The market for automotive semiconductor products has already racked up impressive growth and reached an estimated \$40 billion in 2019. Four interconnected trends—electrification, autonomy, connectivity, and mobility as a service (MaaS)—will dramatically change the characteristics of the typical automobile (Exhibit 2).

Exhibit 2. Four trends reshaping the automotive industry

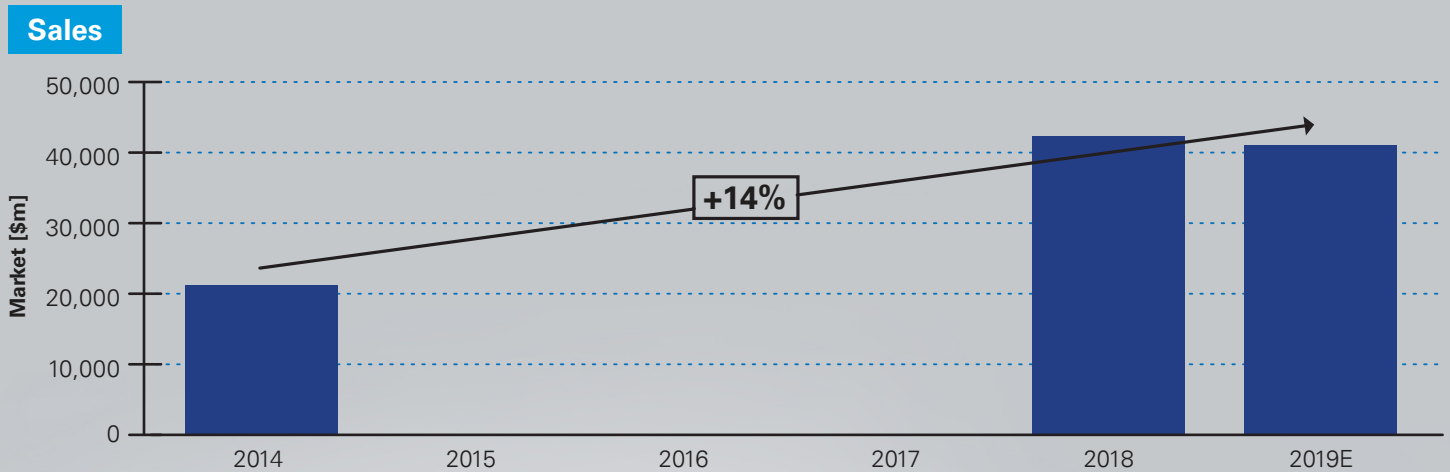


From 2015 to 2019, sales grew at a compound annual growth rate of approximately 6.1 percent, rising from \$30 billion to \$40 billion.³ Today, the most important applications are infotainment, body and convenience, and powertrain (Exhibit 3).⁴

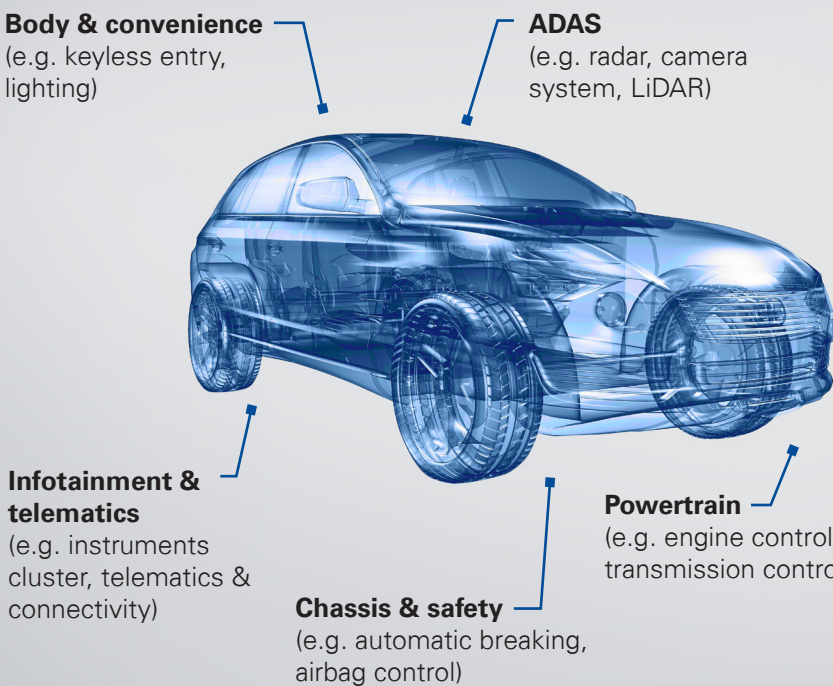
Yet today's vehicles, with all their electronics-based convenience, performance and safety features, represent

just the start of a massive shift in automobile engineering. More and more functionality and value will be based on software and electronics, and on the seamless integration of hardware and software, rather than mechanical parts. This will drive semiconductor demand and alter relationships between automakers, Tier 1 suppliers, and chipmakers.

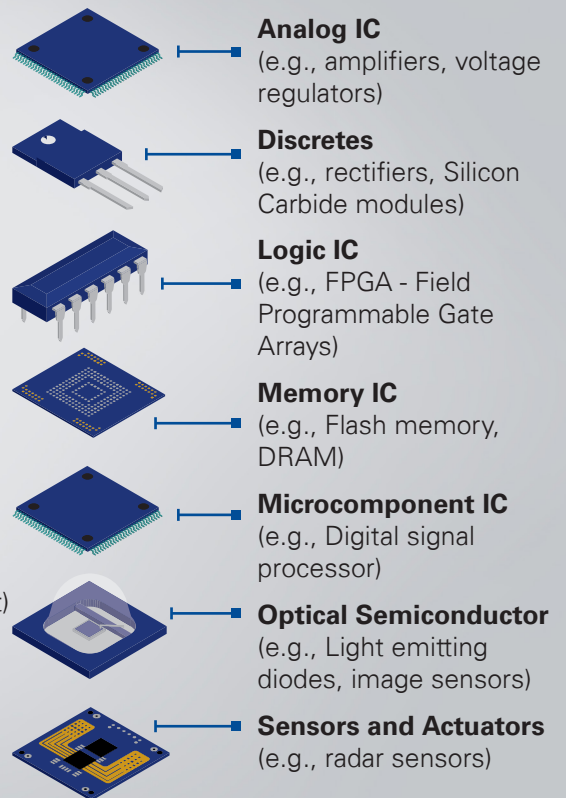
Exhibit 3. The current automotive semiconductor market



Applications examples



Products examples



^{3,4} Source: Gartner, Inc. Semiconductor Forecast Database, Worldwide, 3Q20 Update; <https://www.icinsights.com/news/bulletins/Automotive-IC-Market-To-Display-Strongest-Growth-Through-2018/>

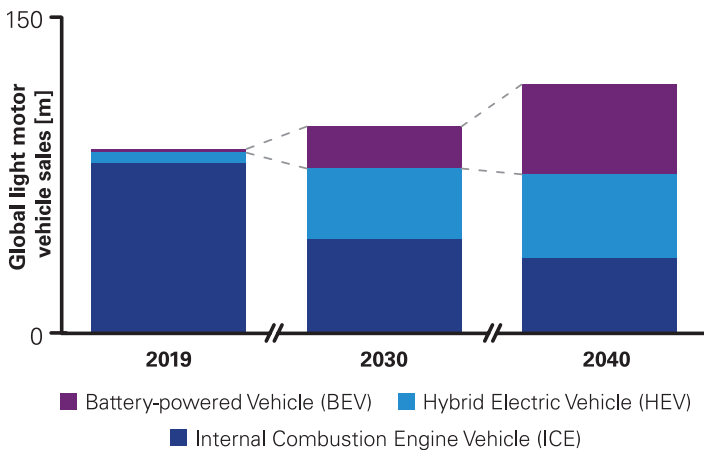


Electric vehicles

How quickly the automotive industry will move from ICE power trains to electric-powered vehicles is a matter of debate, but the electrification of powertrains is under way. Today, battery-powered electric vehicles (BEVs), represents just 2 percent of global light vehicle sales, and new KPMG research indicates that a mass market for EVs is still a decade or more in the future. However, while projections

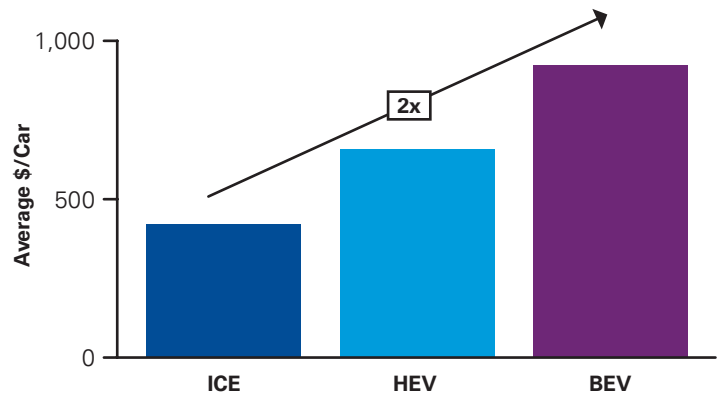
for global EV sales vary widely, most analysts agree that more than 50 percent of vehicles sold by 2030 will have some form of electrification (Exhibit 4). And, as vehicle powertrains move from ICE to electric, semiconductor content (by value) per car doubles (Exhibit 5), due to increased use of discrete semiconductors, compound semiconductors and sensors.

Exhibit 4. Vehicles with some kind of electrification could capture more than 50 percent of the global market by 2030



Source: Based on Credit Suisse Analyst Report, June 26, 2019

Exhibit 5. Average fully electric cars will have twice as much semiconductor content than ICE cars



Source: Based on multiple Industry Earning Reports, KPMG Insights

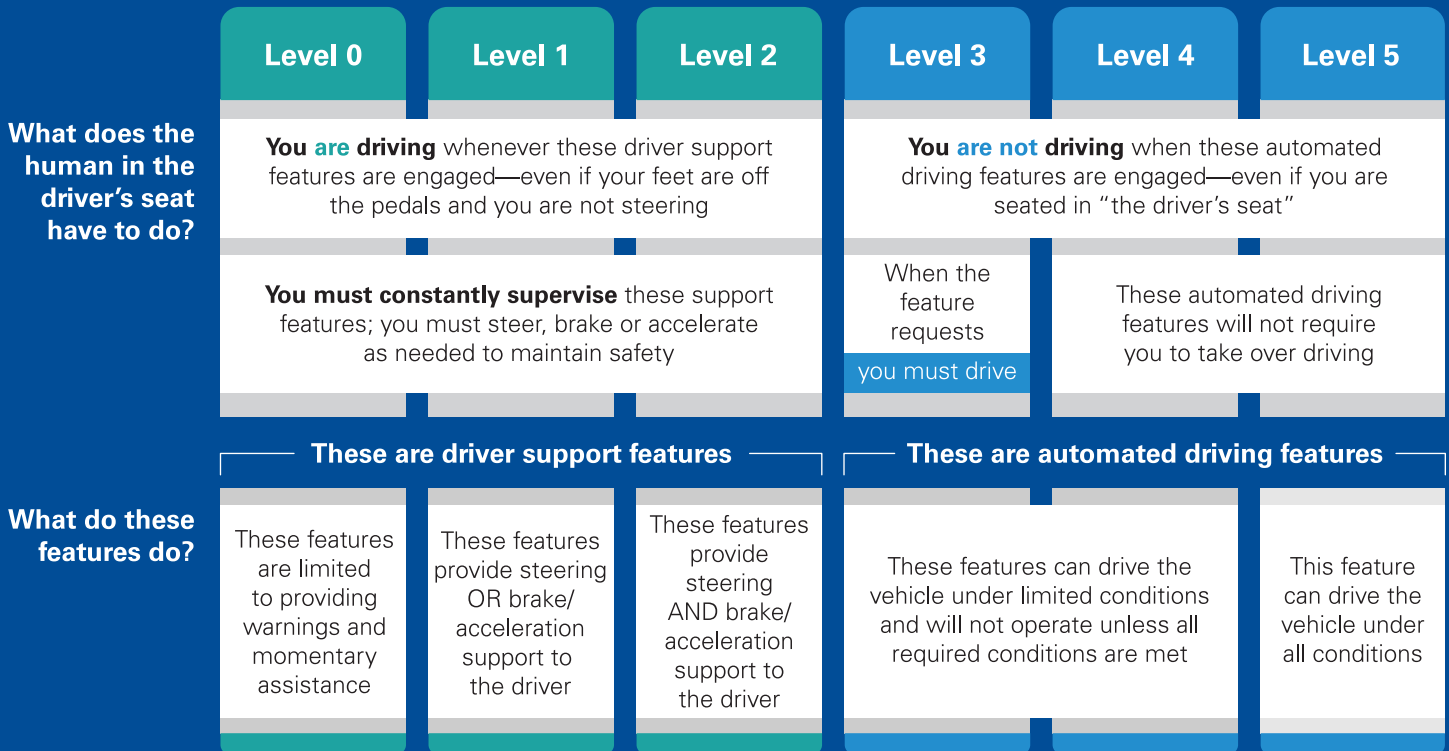


Autonomous vehicles

The industry is racing to design self-driving vehicles. A fully autonomous vehicle that doesn't require a driver (Level 5 on the scale created by the Society of Automotive Engineers, as seen in Exhibit 6) is still far in the future in terms of mass-produced cars. But we expect Level 4 vehicles, which can complete a trip without a driver in a geo-fenced area and under speed limitations, to appear in the next two or three years in commercial fleet operations

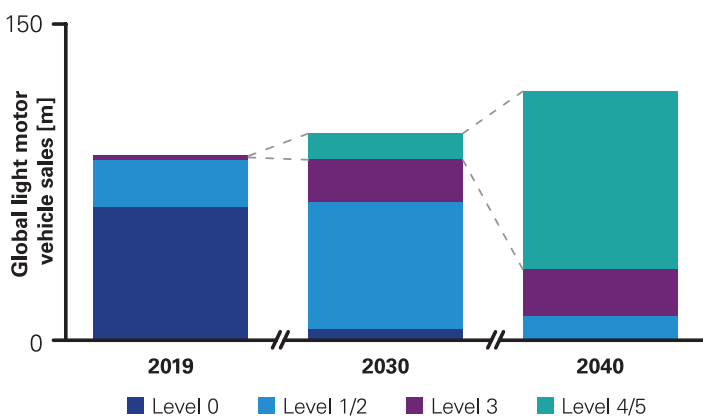
in urban markets. By 2030, most analysts agree that vehicles with Level 4 or 5 autonomy could account for more than 10 percent of total global vehicle sales (Exhibit 7). These vehicles are expected to have eight to ten times the semiconductor content (by value) as a car with no automation (Exhibit 8) and will resemble more and more a supercomputer on wheels than a car of today.

Exhibit 6. Levels of autonomy definition, Society of Automotive Engineers



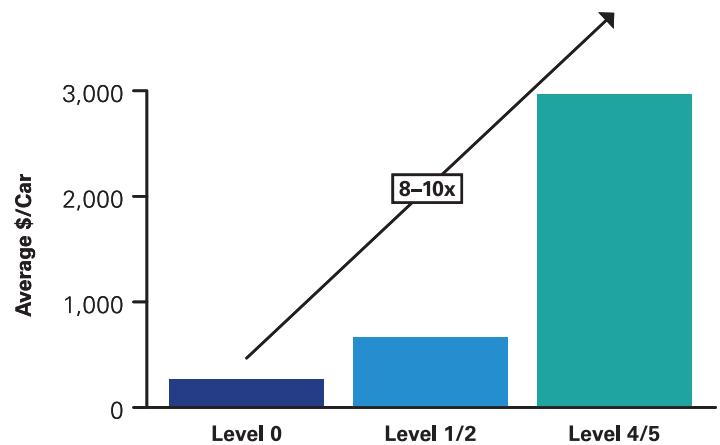
Source: SAE, Society of Automotive Engineers

Exhibit 7. Vehicles with Level 4/5 autonomy could capture 10 percent of the global market by 2030



Source: Based on Auto and Shared Mobility, Morgan Stanley, Sep 2019

Exhibit 8. Average Level 4/5 cars today have 8-10 times the semiconductor content than Level 0 cars



Source: Based on multiple Industry Earning Reports, KPMG Insights



Connected vehicles

Automakers have been building vehicles that connect with the outside world since the 1990s, when General Motors introduced OnStar, a system that included emergency communication and automatic crash notification using GPS and wireless communications. Since then, vehicle telematics systems have evolved to provide navigation, remote vehicle health monitoring, fleet-vehicle tracking and other communications-based services.

Autonomous vehicles will require a whole new level of connectivity. For example, Intel estimates that a connected car could generate at least 4 terabytes of data per day, including navigation, guidance, infotainment, and other kinds of information.⁵ This data has to be stored, secured, transmitted and analyzed with utmost reliability to guide safe vehicle actions. All of these functions drive semiconductor demand, not only in the car itself, but also in the required infrastructure.



Mobility as a Service

Finally, Mobility as a Service (MaaS) offerings are reshaping how people and goods move. The first wave of mobility services—ride-hailing platforms such as Uber, Lyft, Didi and Ola—have already changed how people get around cities in the U.S. and around the world. KPMG analysis shows that 70 percent of the U.S. population lives within 10 minutes

of an Uber or Lyft pickup. Ride-hailing and ride-sharing have already disrupted taxi, delivery and car-rental businesses, and are affecting patterns of automobile ownership in large cities. Now, we are starting to see a second wave of mobility services, aimed at moving and delivering goods rather than people.

When EV, AV, connected vehicles and MaaS converge

While MaaS vehicles do not necessarily need to be connected, autonomous, or electric, we see the convergence of all four trends as a key trigger of MaaS growth. EVs and fully autonomous vehicles will continue to be too pricey for most consumers, but when used in a MaaS fleet, the total cost of ownership of an autonomous, connected electric vehicle changes. In our paper *Islands of Autonomy*, we explain how higher vehicle utilization, the elimination of the driver, and the lower operating and maintenance costs of electric powertrains will enable savings that could rapidly expand MaaS adoption.⁶ Autonomous mobility as a service (AV-MaaS) can emerge as an attractive and cost-effective alternative to personal vehicle ownership in urban areas—as long as reliable connected vehicle technology and necessary infrastructure are in place.

As demand for AV-MaaS vehicles and other advanced automobiles grows, so does the demand for the semiconductors that make them possible. Semiconductors will effectively become the new automotive ICE, Internal Computing Engine.



⁵ Source: “[Intel’s Krzanich Has Seen The Future ... And It’s Data](#),” January 9 2018.

⁶ Source: “[Islands of Autonomy](#),” KPMG, 2018.

How the four trends will affect the semiconductor industry

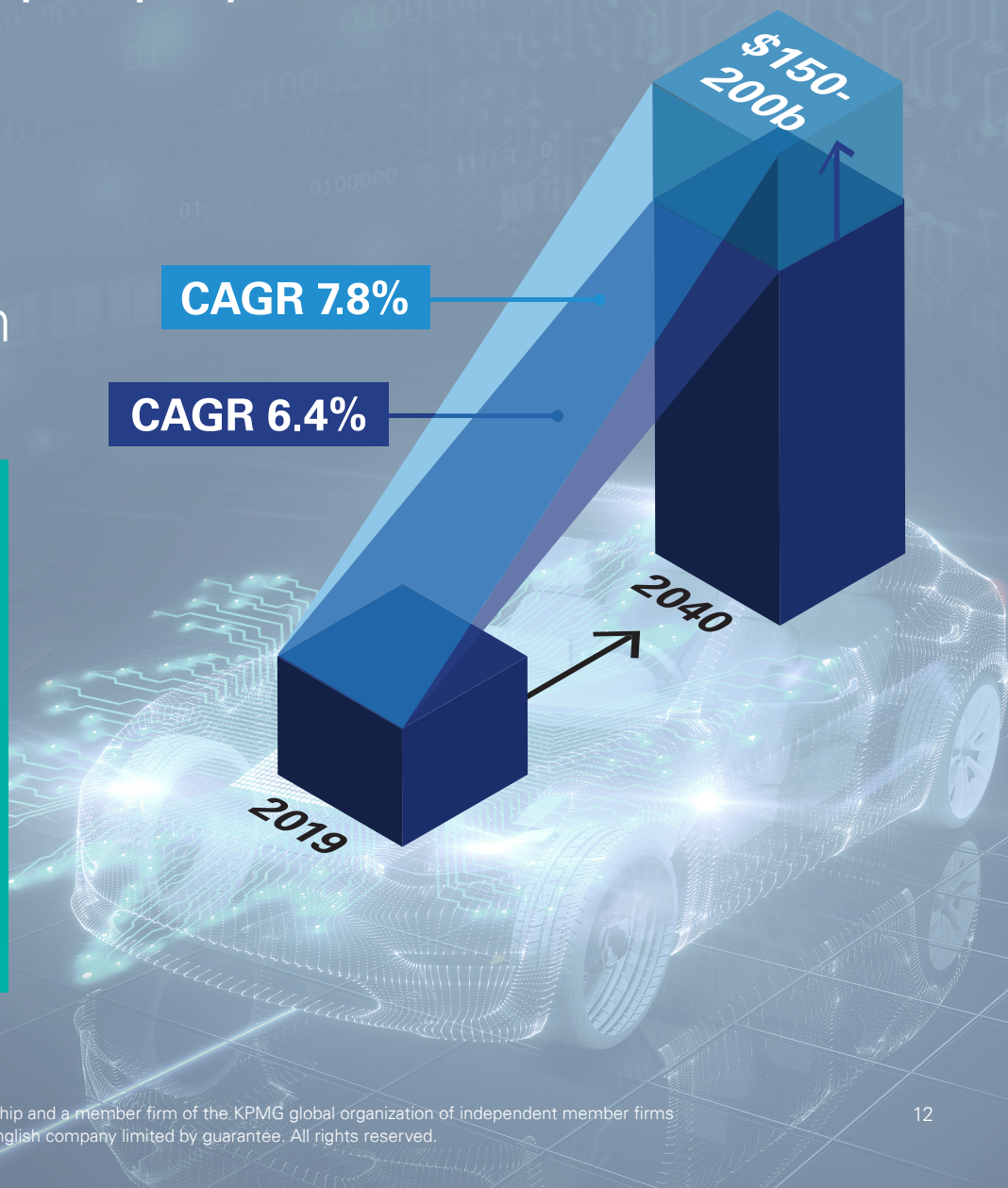
What will the biggest implications of increasing electronic sophistication of automobiles be for the semiconductor industry? The most obvious impact will be accelerating demand. But getting into the automotive sector or expanding an existing position will also require investments in innovation to develop new products, new materials and new packaging techniques. Finally, to win in the expanding automotive sector, semiconductor suppliers should contemplate the need for new organizational setups, manufacturing processes, and go-to-market strategies.

Demand will more than quadruple by 2040...

Exhibit 9.

The automotive semiconductor market can potentially reach **\$200b** by 2040

...and this doesn't include semiconductors used in related applications that are not on-board of the vehicle, like charging stations, V2X infrastructure and cloud computing systems.



Source: KPMG Insights

Today, the two biggest forces behind growing semiconductor demand in automotive applications—autonomy and electrification—still play a minor role in the overall automotive industry. But that will change quickly when technology capabilities and costs improve, when consumers more broadly accept the new type of vehicles, and when regulations catch up. Based on demand projections for autonomous and electric vehicles and KPMG insights, we project that automotive semiconductor sales could grow by a factor of 3.5 to 4.5 by 2040. That implies a compound annual growth rate between 6.4 percent and 7.8 percent (Exhibit 9).

This number includes only semiconductors used on the vehicle. In reality there are many automotive-related applications which will drive semiconductor demand, too. Examples include: EV charging stations, infrastructure sensors and connectivity as well as servers to sustain the cloud computing infrastructure required for autonomous

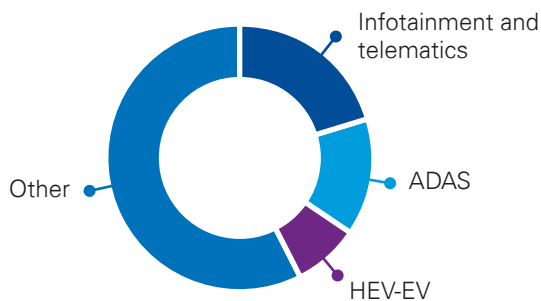
vehicle development and ongoing operation. We will be exploring these applications in future papers.

This growth will be led by uses in advanced driver assistance systems (ADAS), infotainment and telematics, and electric powertrains. Autonomous driving will require both ADAS and telematics sub-applications for safe operation (as well as a perfectly integrated hardware and software platform). And, with riders' attention freed from driving, riders in self-driving vehicles are expected to spend the time using more advanced and expensive in-vehicle infotainment systems, spurring the growth of infotainment applications.

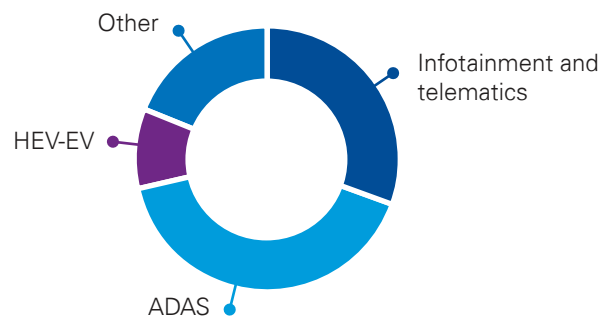
This means that, in the coming decades, the mix of applications for semiconductors in vehicles will shift. Chips used in ADAS, infotainment and telematics, and electric powertrains could capture 80 percent of the market in 2040 up from 43 percent in 2019. This represents a 10 percent plus compound growth rate for all three applications (Exhibit 10).

Exhibit 10. ADAS, Infotainment & Telematics, and Electric Powertrains applications will experience the highest growth rates between 2019 and 2040 and will dominate the semiconductor market by 2040

2019 market share



2040 market share



Source: 2019 Charts/graphics created by KPMG based on Gartner research (Semiconductor Forecast Database, Worldwide, 3Q20 Update); 2040 Charts/graphics created based on KPMG insights

KPMG Automotive Semiconductor Market Model

The Model: The semiconductor market model provides KPMG with a tool to forecast detailed semiconductor demand by application, product type and vehicle type (powertrain and level of autonomy) from 2019 to 2040. This enables us to quickly simulate how the semiconductor market could evolve based on changing vehicle demand, thus helping semiconductor companies make more informed and timely decisions.

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The Methodology: KPMG leveraged industry knowledge, expert interviews and detailed automotive semiconductor data published by Gartner.

Gartner data (Semiconductor Forecast Database, Worldwide, 3Q20 Update) consists of detailed revenue and unit data by automotive semiconductor application (e.g., General Purpose/Discrete/Diodes) for years 2018 to 2024.

KPMG married the data with its own data on type of vehicle (vehicles by powertrain and level of autonomy) and applied proprietary insights to calculate revenue and units by applications, powertrain and level of autonomy for years 2018 to 2024. We then forecasted semiconductor units to 2040 based on vehicle volume and mix projections, and semiconductors ASP (average selling price) based on semiconductor units volume. The model has been validated against industry published data and experts' opinion.

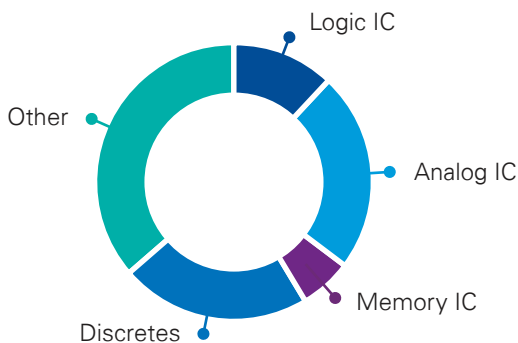
The shift in applications will translate into a change in the mix of chips that are sold, too. Logic IC and memory chip sales are expected to benefit the most from autonomous and connected vehicles. Electric powertrains will drive sales of analog ICs and discrete semiconductors.

Demand for some types of chips could evolve in different ways, depending on design decisions. For example,

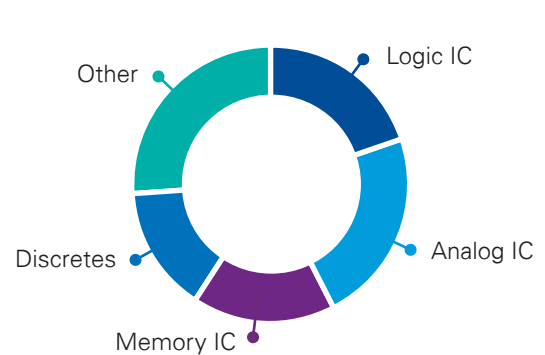
the automotive industry has not yet decided how much memory or processing power should be onboard the vehicle or in the cloud. Exhibit 11 shows the expected mix of products for the three leading applications in 2040, and Exhibit 12 shows the intersection of applications and product.

Exhibit 11. Logic IC, Analog IC, Memory IC and Discretives will continue to dominate the semiconductor market till 2040

2019 market share

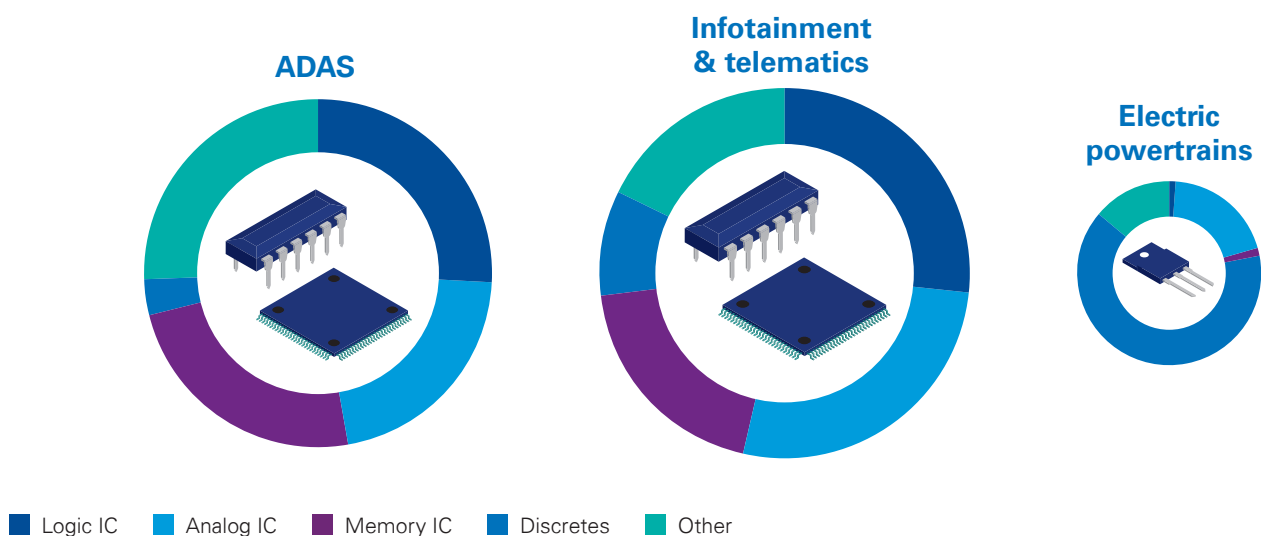


2040 market share



Source: 2019 Charts/graphics created by KPMG based on Gartner research (Semiconductor Forecast Database, Worldwide, 3Q20 Update); 2040 Charts/graphics created based on KPMG insights

Exhibit 12. In 2040, just like today, different products will dominate different applications



Source: KPMG Insights

Investments in innovation will be needed, as well as critical design and technology decisions

The semiconductor industry will be called on to develop many new solutions for new automotive designs. Not only will the industry have to develop new IC designs, it will also have to create new packaging techniques, new materials and new system designs. This means significant investments and rigorous management of semiconductor companies' R&D and M&A portfolios.

In the coming years, semiconductor executives and engineers will be faced with a series of critical decisions about where to invest, based on how automotive demand will evolve. An example of the difficulty facing semiconductor executives is seen in memory and logic components.



On the Memory, RF, Analog and Interface side, there are complex design issues. Using smaller processing nodes today doesn't deliver the same performance, cost, and size benefits as it does for logic circuits, says Mike Noonan, CEO of Mixcomm, a wireless communication technology company.



That poses a design challenge. One way around this is "heterogeneous integration," which involves packaging silicon dies processed separately within a single module. This approach has its own packaging and materials challenges but has been successfully applied in mobile phones and data center application and is now being considered for automotive.⁷



In the future, innovation in memory technology could upend the current approach, says Anthony Le, VP of Marketing at Macronix, an integrated device manufacturer in the non-volatile memory market.



On the logic side, the system designer can choose between ASICs (application-specific ICs) and FPGAs (field-programmable gate arrays). FPGAs, thanks to their flexibility, are commonly used in low-volume, emerging applications in industries that are still developing standards. ASICs usually deliver more optimized performance and are better suited for high volume or highly specialized products. Both product categories will benefit from automotive applications.



The industry will continue to use FPGA for at least a decade, until volumes are large enough for semiconductor suppliers to develop customized solutions, says Steve Glaser, former senior vice-president of Xilinx, a supplier of programmable logic devices, and a managing director at Copia Growth Partners.



Electrification poses its own innovation challenges, most importantly finding ways to extend battery life. For high-efficient power applications at high temperatures, SiC (Silicon Carbide) chips are emerging as a winning solution.⁸

⁷ Source: "[Amkor Delivers Industry's First Package Assembly Design Kit to Support Mentor's High-Density Advanced Packaging Tools](#)," Amkor, July 18 2018.

⁸ Source: "[The potential of Silicon Carbide for Automotive Applications](#)," EE News Automotive, June 14 2017.

And automakers are a different kind of customer

The automotive market is unlike other large semiconductor markets such as consumer electronics. Volumes are smaller and development cycles are longer. This means semiconductor companies that want to enter the segment or increase their revenue in the segment will have to adapt.

To start, serving automakers may require new business-case evaluation methods. Automotive design cycles can easily take three to four years from concept to production, as opposed to the one to two years for consumer applications. Volumes are also much lower, often less than one million per year for a specific customer as compared to the tens of millions for mobile customers. Product supply needs to be guaranteed for at least ten to fifteen years. As vehicles become more and more silicon- and software defined devices, the industry is realizing just how complex the optimal integration of hardware and software can be. This means ROI and unit pricing considerations will be completely different from what chipmakers are accustomed to in consumer electronics. Companies will need frameworks to develop financial justifications that are tailored to the automotive business and to the company and its strategic priorities.

Companies often find that the special requirements of automotive customers can be difficult for the existing organization to meet. To address this, some semiconductor suppliers have formed dedicated organizations for their automotive businesses and have adapted their safety, reliability, and design methodologies to better serve customers in the automotive sector.

There are other challenges, too. For example, the chip industry is beginning to realize just how complex the optimal integration of hardware and software can be in advanced vehicles.



Automakers are recognizing it is not just about the raw specs of the chips, but how their technology partner can deliver a robust AI computing platform that extends from the cloud to the car, and includes a complex in-vehicle software stack capable of pre- and post-processing numerous data-streams while running dozens of AI applications, says Danny Shapiro, NVIDIA

senior director of automotive.



Also, the car of the future and the infrastructure needed to support it are still moving targets. The infrastructure to support connected cars is still being designed and won't be an exact duplicate of the consumer mobile infrastructure (e.g., there is still significant discussion in the industry about the proper balance between edge- and cloud-computing). This means the specific electronic system designs within the vehicle that are communicating with this distributed infrastructure are still subject to significant evolution.

Semiconductor companies will not only need to create the individual ICs but also understand the continually evolving application in which it will reside. This means that semiconductor suppliers will need to collaborate with the automotive OEM and with emerging automotive cloud providers. In most cases, they will need to hire additional applications and software engineers.

The examples above are not exhaustive, but they give an idea of the complexity facing semiconductor executives deciding when and where to invest.

A new automotive market, new players, new relationships

Other players across the automotive supply chain will need to adapt to the trends transforming the industry and this in turn will affect how semiconductor companies operate. Automakers are looking at ways to accelerate innovation to create new autonomous, electric, and connected cars. New players are piling into automotive electronics. And traditional suppliers are feeling the heat.

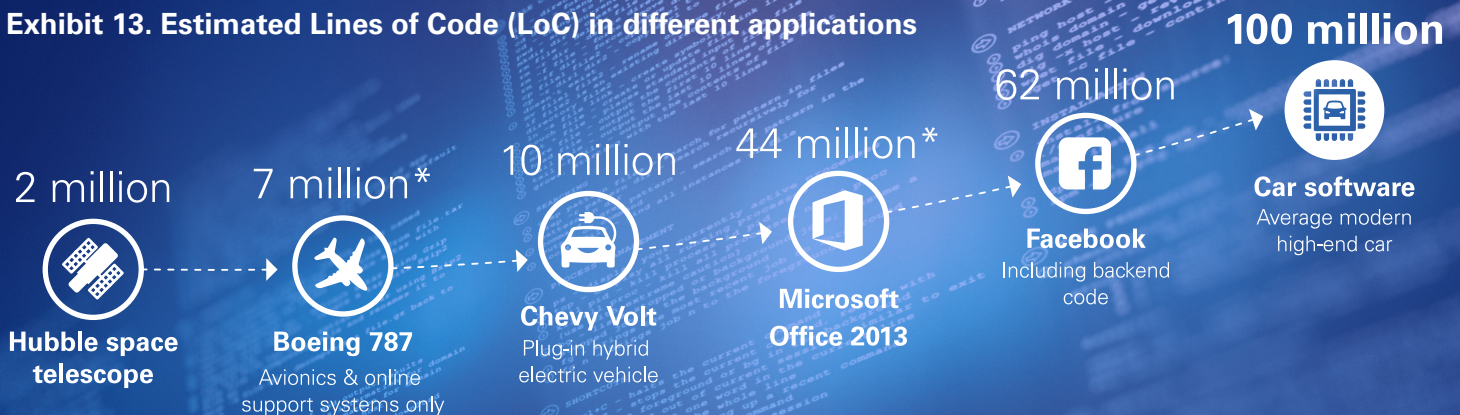
Automakers are getting closer to semiconductor providers

As electric, autonomous and connected vehicles become a reality, automakers are forced to reconsider the capabilities, skills and talent they need to succeed and in the process they are collaborating more closely with their semiconductor and electronics suppliers.

A decade ago, Tesla recognized that electronic design and software development would be critical strategic capabilities and it has now developed its own IC designs for artificial intelligence applications.⁹ Other automakers may not be designing their own chips, but they recognize they have to take a far more active role in the technology that goes into their products. Unlike in the past, when automakers dealt mostly with the Tier 1 suppliers, they are now reaching out directly to semiconductor suppliers and working as collaborators on key components.

Automakers are also recognizing that as cars become smarter they will rely increasingly on software to operate.⁹ It takes an estimated 100 million lines of code to keep an advanced car running today (Exhibit 13).¹⁰ Artificial intelligence (AI) applications needed for autonomous vehicles are increasing the need for sophisticated software solutions on board the car and in the cloud. It is clear that automakers will have to hire more software engineers. One automotive maker told us it plans to double its software engineering force in the next few years and we expect automakers to forge many collaborative relationships with software companies. To keep up with the challenges of electrification and autonomy, automakers are also stocking up on talent in power-electronics and sensors.

Exhibit 13. Estimated Lines of Code (LoC) in different applications



⁹ Source: Sean Hollister, "Tesla's new self-driving chip is here, and this is your best look yet," The Verge, April 22, 2019.

¹⁰ Source: Jeff Desjardins, "How Many Millions of Lines of Code Does It," Visual Capitalist, February 8, 2017

*Numbers rounded to the nearest whole number

New players, including software suppliers, are entering the supply chain

The automotive industry's evolution toward autonomous, electric, and connected vehicles will require unconventional thinking and new business strategies. This is opening the automotive supply chain to a number of new entrants (Exhibit 14), which will press semiconductor companies to adapt their go-to-market and innovation strategies.

One category of entrants in the supply chain is new automakers, such as Rivian, a U.S. EV developer backed by several key industry players, and Nio, a Shanghai-based startup focused on EVs and autonomy.

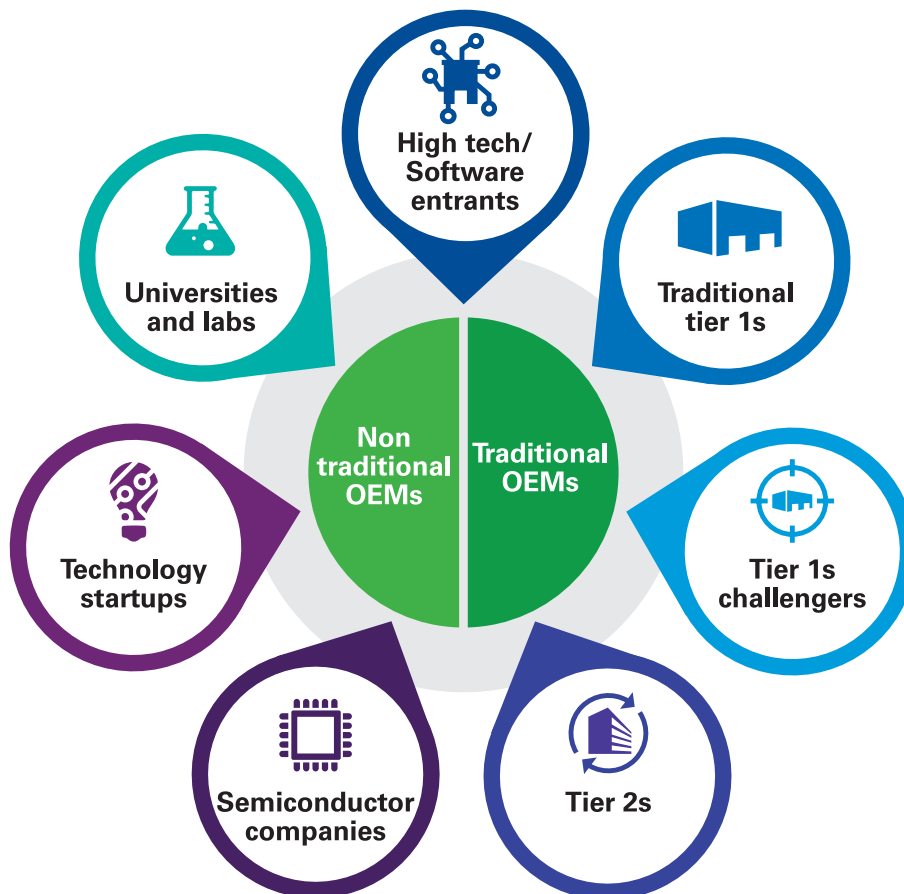
Meanwhile, established electronic manufacturing service providers that used to be more focused on consumer are leveraging their complex system development expertise and manufacturing processes to serve emerging applications for automotive.



The optimal integration of hardware and software needed for these new complex automotive applications requires a holistic system approach, a multidisciplinary and global development team, and robust manufacturing processes. Flex has been able to leverage its consumer and server expertise to provide innovative solutions to automakers quickly", says Eric Hoarau, Head of Automotive Innovation at Flex, an electronic manufacturing service provider.



Exhibit 14. Today, industry players interact with a wide variety of companies to enable new vehicle features



Semiconductor incumbents will also have to deal with new entrants in the semiconductor sector itself. These include technology startups or new automotive entrants that are focused on specific subsystems or applications. Semiconductor companies need to decide when and how to work with these companies—and when to compete. The changing collaboration landscape created by new entrants in automotive can be seen in the partner ecosystems that many companies show on their websites.

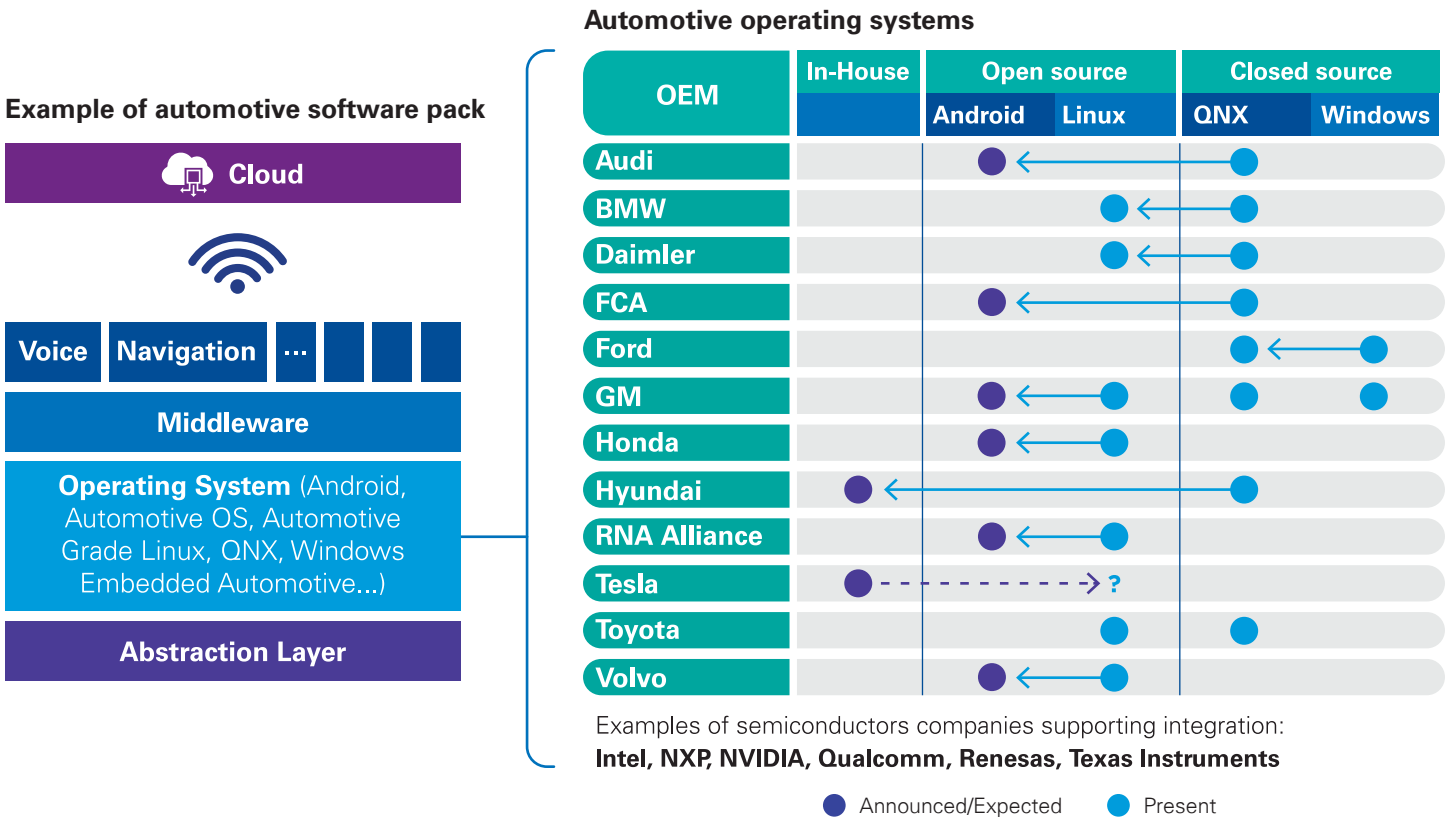
A more disruptive group of entrants could be the big-name tech companies that are developing automotive software platforms. The impact these companies will have is still unclear, but what is clear is that the contest for providing a widely accepted standard for the basic software platform of advanced automobiles will have implications across the industry. Like any other computing device, the car needs a foundational operating system on top of which other software systems will run (Exhibit 15). This usually runs on an abstraction layer that separates the operating system and the applications from the physical hardware

so that the software can run on multiple vehicles. Finally, there is a need for a vast array of complex applications for autonomous driving, voice control, driver monitoring, V2X (Vehicle to Anything) applications, etc.

A key competition is the race to offer the winning automotive operating system. Tesla has developed its own system, Apple is rumored to be developing a solution, Google has Android Automotive OS (not to be confused with Android Auto), and several automotive suppliers have partnered with BlackBerry/QNX and NVIDIA Drive OS (Exhibit 15).

The winners of the operating system contest will gain important advantages. It will have the edge in providing applications, similar to how Microsoft leverages Windows, and gain access to customer data that can be used to sell other services, just like in the mobile world. This contest is still wide open. But the rest of the supply chain, including semiconductor companies, will need to continue parallel development.

Exhibit 15. Examples of automotive software stack and operating systems



Source: "Global Automotive Operating Systems Market," Frost & Sullivan, January 2019, and KPMG research
 Source: "Tesla starts to release its cars' open-source Linux software code," ZDNet, May 30, 2018.

Automakers will ultimately own the data generated by the vehicle, but data not needed for driving, safety, security or maintenance (e.g., entertainment choices) will flow to software providers, as in the mobile world. How the

automakers set up the relationships with the software providers will determine how the customer behavioral data is divided.

Tier 1 suppliers may face the biggest challenges and opportunities

Tier 1 electronics suppliers are aware of the implications of the closer collaboration between automakers and chipmakers. And they see the threat to pure hardware suppliers from the rise of software players—potentially winning more of the value and leaving less for hardware manufacturers and assemblers. As a result, Tier 1 electronics suppliers are making significant investments in innovation, including in software (e.g., Siemens acquiring Mentor Graphics) or even in their own chip fabrication facilities¹¹ and still have the opportunity to capture value as the industry needs shift.

Despite the challenges and threats, for now, Tier 1s remain the only players that can meet automakers' needs for volume, quality and low cost. Industry experts interviewed for this research agreed that Tier 1s are probably in the most difficult spot, but none could identify a viable alternative or predicted that any Tier 1s would disappear. Tier 1 electronic suppliers will remain an important customer for semiconductor companies and a critical partner for automakers in the foreseeable future and still have the opportunity to capture value as the industry needs shift.

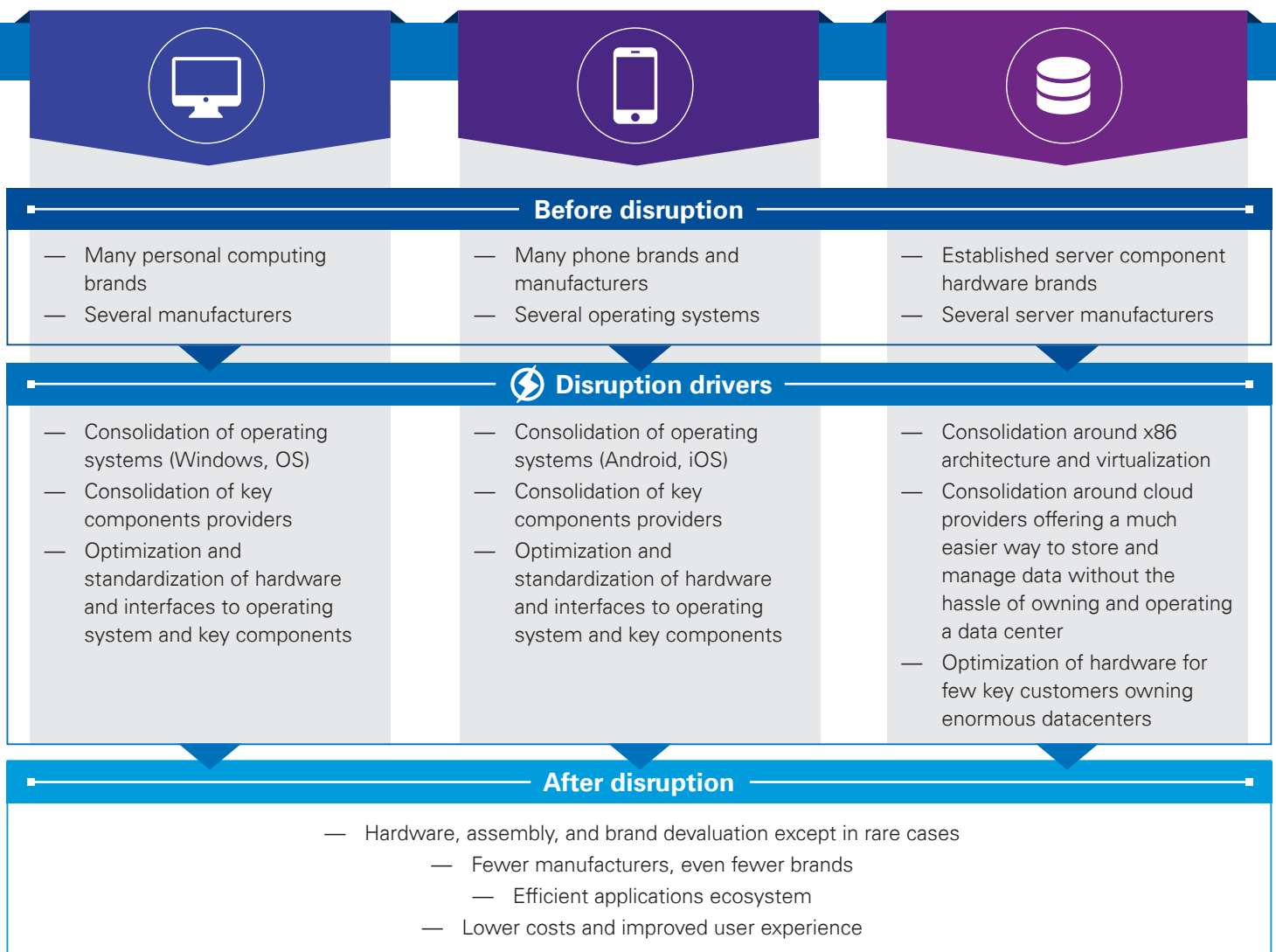
¹¹ Source: "[Bosch poised for leap in e-mobility technology](#)," Bosch, October 8 2019.



Learning from history: past technology-driven industry disruptions

Other major industries have undergone technology-driven disruptions that completely changed the value chain, the player landscape, and their way of doing business. While the automotive industry has its own specific characteristics, these industries offer lessons about the positive paths to take and the pitfalls to avoid in building robust business strategies.

Mobile, data centers and personal computers industries went through significant transformation due to technology and data driven innovation...



...and potentially similar disruption patterns are emerging in the automotive industry



Before disruption

- Many established vehicle brands
- Several proven Tier 1s manufacturers

Disruption drivers

- Consolidation of operating systems?
- Centralization of the automotive electronics architecture?
- Consolidation of key components providers (e.g., autonomous driving systems)?
- Optimization and standardization of hardware and interfaces to operating system and key components?

After disruption



What's next? Strategic questions for automotive and semiconductor companies

As the industry moves into the new era of electric, autonomous, and connected cars, and semiconductors become the new differentiating technology—the Internal Computing Engine—both automotive and semiconductor executives will be faced with many critical strategic questions.

This following list of questions is in no way exhaustive, but it gives an idea of the complex decisions facing senior executives. The answers will depend on the specific company's technology, competitive position, and resources.



Automakers and Tier 1 suppliers

As vehicles become more and more software- and electronics-defined devices to meet the demand for increased safety, comfort and improved user experience, automakers and Tier 1 suppliers must decide how to best leverage and integrate the critical semiconductors, software and data that enables them.



Should automakers develop their own complete silicon and software solution? How should they balance the need to have optimally integrated hardware and software from the car to the cloud, supporting an efficient, secure and appealing offering, while retaining control of the platform and of the user experience?



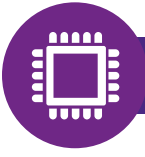
How should automakers and Tier 1 suppliers acquire the needed software skills? Should they partner with or acquire software companies or develop skills in-house? How broad and deep will in-house knowledge need to be?



How will automakers and Tier 1s meet the needed data-security standards across their entire supply chain? How could this data create new revenue streams?



Should automakers change the way they engage semiconductor companies, especially for critical components? How will this affect their relationships with important Tier 1s suppliers?



Semiconductor designers and manufacturers

As semiconductors move to the heart of automotive design and as the market and the supply chain rapidly evolve to meet demand, semiconductor companies have great opportunities, but must effectively manage the risks and adapt their go-to-market strategies.



How should semiconductor companies craft investment and partnership strategies to capitalize on the four automotive megatrends over the coming decades? How could the progress towards these long-term goals be measured to determine if the strategy will pay dividends?



Where should semiconductor players focus to take advantage of the New ICE age—on integrated solutions or on individual components? Does a company need to provide the most advanced piece of silicon in the vehicle to have a profitable portfolio of automotive semiconductor products?



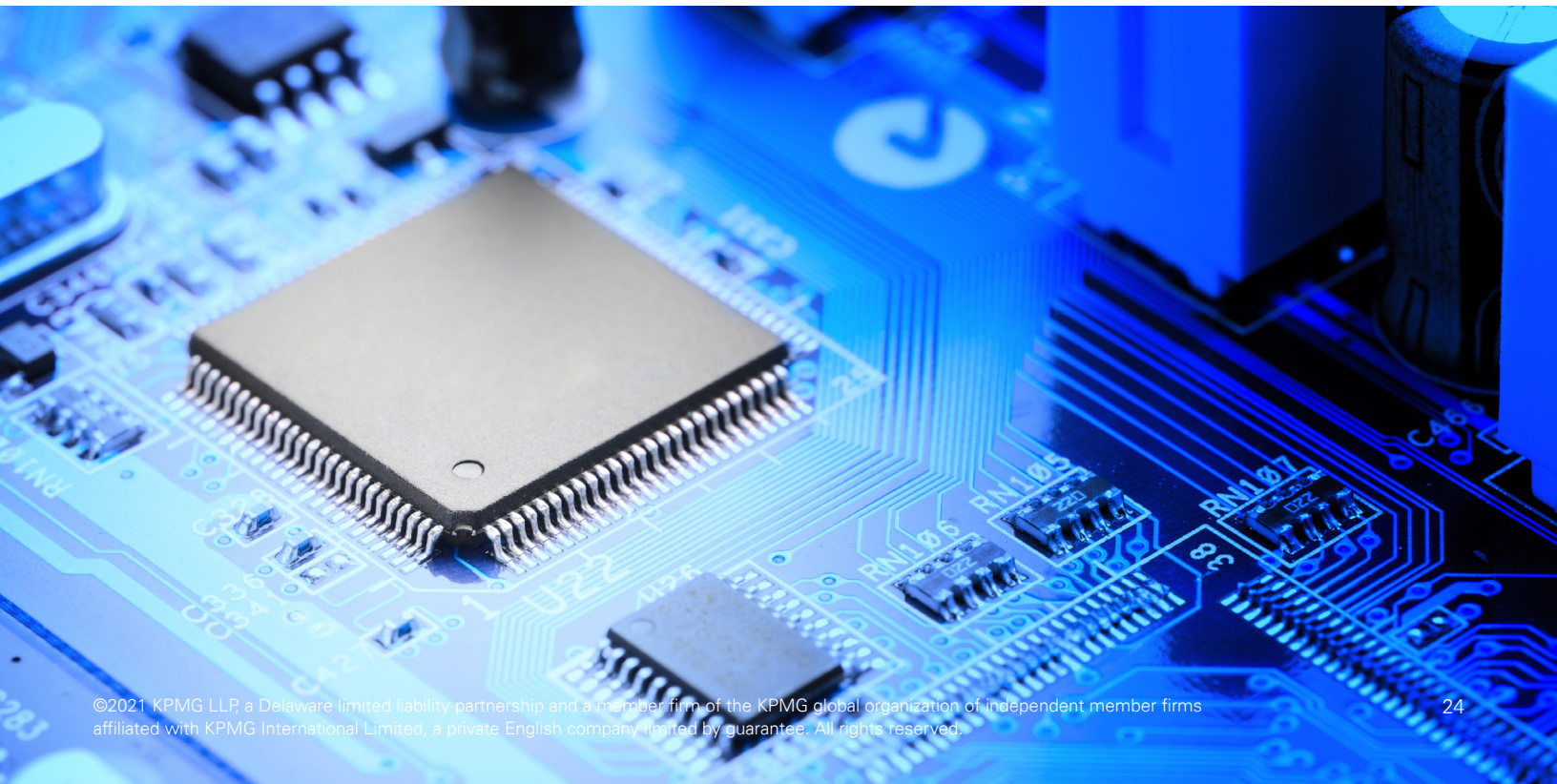
What is the optimal software strategy, and how will the company acquire the needed software skills? Should it partner with or acquire software companies or develop skills in-house?



What is the optimal R&D strategy? How big a role will M&A play in amassing automotive capabilities vs. in-house innovation?



How do the longer development times and product lifecycles affect semiconductor investment strategies and R&D portfolios?



Call to action

We believe that the opportunities for automotive semiconductor suppliers and for the whole automotive supply chain are great. But the road from now to a world where electric, autonomous, and connected cars are commonplace will be bumpy and require many hard decisions. We encourage semiconductor executives to:



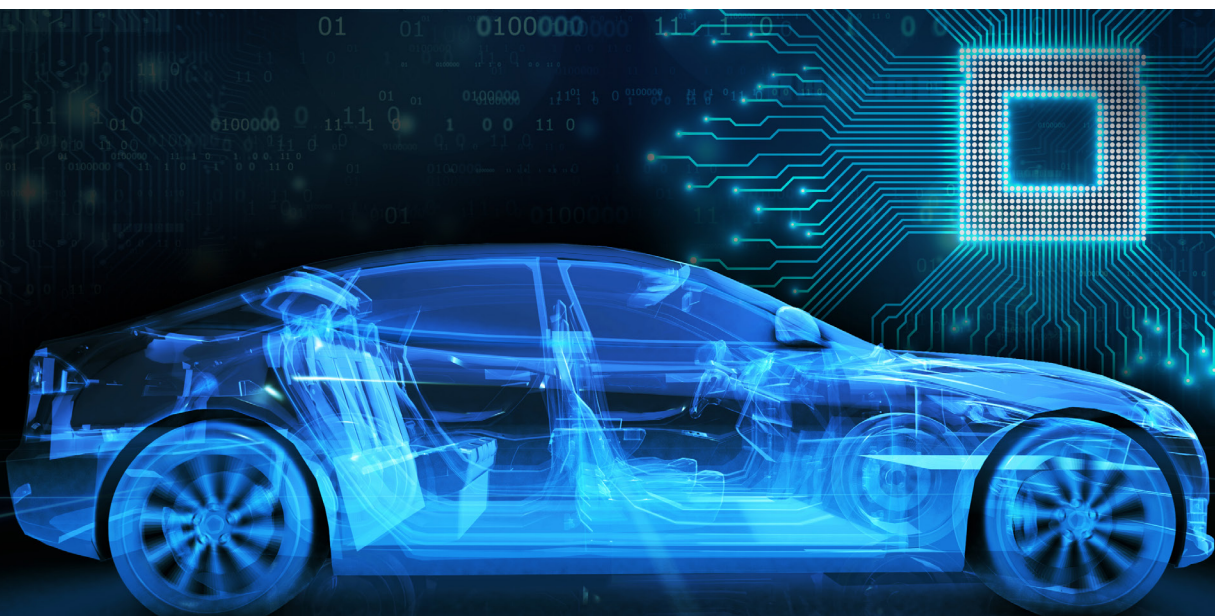
Assess the current go-to-market approach and product portfolio to determine if you are well positioned to ride the new automotive trends.



Consider a comprehensive development strategy, leveraging both internal R&D and strategic M&A, to balance the risk of unproven technologies and the capabilities required to succeed long-term.



Analyze and quantify the risk and impact of disruptions to current relationships across the automotive value chain.



How KPMG can help

KPMG Strategy combines deep expertise in both automotive and semiconductor industries, advanced analytical tools and experienced advisory capabilities to produce timely and actionable advice for our clients.

KPMG supports our clients' journey as they navigate the complete strategic arc from strategy development, to deal identification and assessment, to target integration and performance improvements and finally to divestitures.

Our semiconductor and automotive expertise can help you navigate the accelerating and changing automotive semiconductor landscape.

Project examples include:

- 1 Develop strategic options to minimize investment risks when engaging with emerging players
- 2 Assess potential development partners and acquisition targets to acquire critical new skills and accelerate innovation
- 3 Integrate companies that have been acquired in an efficient and timely manner without losing innovation momentum
- 4 Assess portfolio, talent and infrastructure readiness as technical and software-related complexity increase

Learn more at:

[KPMG Semiconductor Global Practice](#)

[KPMG Automotive Institute](#)

Other insights you might be interested in:



Semiconductors: As the backbone of the connected world, the industry's future is bright



Semiconductors: Can the surge continue?



The right to win in semiconductors



Smarter cars, but more distracted drivers, too



Autonomy delivers: An oncoming revolution in the movement of goods



Islands of autonomy

Authors



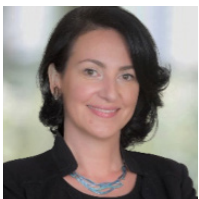
Scott Jones

Scott is a principal in the firm's Global Semiconductor practice and member of KPMG in the United States' Technology, Media & Telecommunications practice. He has more than 15 years of experience as a program manager in the semiconductor industry, equity analyst covering the semiconductor sector, and consultant serving technology companies. Scott has delivered performance improvement services in areas such as R&D portfolio management, financial modeling of advanced technologies, M&A strategy, post-merger integration, and operating model transformation.



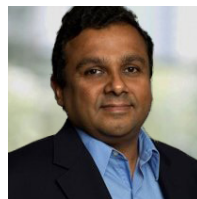
Gary Silberg

Gary is the Global Automotive Sector Leader for KPMG. With more than 25 years of business experience, including more than 14 years in the automotive industry, he is a leading voice in the media on global trends in the automotive industry. Gary advises numerous domestic and multinational companies in areas of strategy, mergers, acquisitions, divestitures, and joint ventures. For the past five years, he has focused on the intersection of technology and the automotive industry, with groundbreaking research on driverless cars, connectivity, and mobility-on-demand services.



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Bala Lakshman

Bala is a Managing Director in the KPMG Strategy Practice, with more than 18 years of experience in helping companies develop their growth strategies. He specializes in the automotive sector and primarily works with automakers, Tier 1 suppliers, and investors. His work has focused on helping clients plan for the inevitable disruptions in automotive including vehicle autonomy, mobility on demand, connected vehicles and electrification.

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