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# ***Connected Car Study 2015***

**&**

**Racing ahead  
with autonomous  
cars and digital  
innovation**



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# Executive summary



**In 2015, our annual study** of “connected car” technologies shows innovation racing ahead as auto makers unveil new digital services and autonomous driving features. The connected car is an automobile designed with direct access to the Internet, enabling automated links to all other connected objects, including smartphones, tracking devices, traffic lights, other motor vehicles — and even home appliances. Volkswagen and Daimler led the industry in a year that saw high general levels of innovation in infotainment systems and safety-assistance technology. We foresee annual sales of connected car technologies tripling to €122.6 billion by 2021. This is a slight slowdown in adoption speed compared to earlier estimates, attributable to the decision by European regulators to give OEMs a three-year extension until 2018 to install automatic emergency calling systems.

Both premium and volume auto makers clearly see connected car technologies as essential to their futures. They also realize that overall vehicle prices aren’t rising as rapidly as the prices charged for digital capabilities. This means returns on investments in traditional car components are shrinking.

Over the next five years, the connected car could disrupt the entire automotive ecosystem. The industry will undergo fundamental change as semi-autonomous driving emerges, followed by an eventual shift to full autonomous driving. Auto makers that have always seen themselves as product suppliers will take on a new identity as providers of mobility services. This will open the door to lucrative new digital revenue streams, especially as they begin to explore opportunities in other digital areas such as entertainment, commerce, and monitoring a driver’s health and fatigue level.

Of course, auto makers aren’t the only ones pursuing these opportunities. Technology companies such as Apple and Google have staked their own claims to the connected car and autonomous driving markets. Auto makers will need new capabilities and cultural change to compete.



No one will win, however, if security concerns undermine consumers' trust in connected car technology. Recent widely reported incidents have focused public attention on the vulnerability of Internet-enabled autos to hacking. To ease these fears, auto makers need to embed security in every aspect of their designs. Those that convince consumers their digital networks are secure will win the trust essential to capturing the connected car opportunity.



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# *The connected car accelerates*

The annual Connected Car Study conducted by Strategy&, the strategy consulting team at PwC, tracks the growth of connected car technologies and their impact on pricing, sales, and innovation in the auto industry. The 2015 study shows innovation accelerating as more manufacturers develop smart driving systems. Recent advances include BMW's remote parking valet, which autonomously parks a car after passengers exit, and Volkswagen's Emergency Assist, which automatically stops a car in an emergency. All OEMs are seeking a path for creating value in this digital arena. At the high end, car companies and their suppliers are differentiating themselves by creating digital experiences that stand out in a crowded market. Mass-market auto makers are looking to incorporate basic digital capabilities on a cost-effective basis. This may require them to join forces with outside partners.

Connected car developments continue to center on seven functional areas:

- **Autonomous driving:** Operation of the vehicle without a human driver at the controls, existing only on a partial basis. Examples include self-parking cars, motorway assistance, and the transportation of goods by trucks on well-delineated routes.
- **Safety:** The ability to warn the driver of road problems and automatically sense and prevent potential collisions. Examples include danger warning signals and emergency call functions.
- **Entertainment:** Functions that provide music and video to passengers and the driver. Examples include smartphone interfaces, Wi-Fi or Local Area Network hotspots, access to social networks, and the "mobile office."
- **Well-being:** Optimization of the driver's health and competence. Examples include electronic alerts that detect or mitigate fatigue, and other forms of individual assistance.



- Vehicle management: Support for minimizing operating cost and increasing comfort. Examples include remote control of car features, displays of service and vehicle status, and the transmittal of traffic data.
- Mobility management: Guidance on faster, safer, more economical, and more fuel-efficient driving, based on data gathered for the vehicle. Examples include real-time traffic information displays, displays of repair and service-related information, and the transfer of usage data.
- Home integration: Links to homes, offices, and other buildings. Examples include the integration of the automobile into home alarms or energy monitoring systems.



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# ***Today's market: Prospects and competition***

We expect connected car technologies to generate €40.3 billion in end-customer spending next year. Safety and autonomous driving are the largest categories, accounting for about 61 percent of the total. In the premium automobile segment, the spending on digital technology is expected to rise to 10 percent of total vehicle sales by 2021, more than double the current level of 4 percent.

OEMs and Tier 1 suppliers are making the related R&D investments despite the uncertain economics of the connected car. Many elements of the connected car replace older digital and non-digital features.

In the premium automobile segment, luxury car auto makers see these features as “table stakes.” They are necessary to stay competitive and avoid price dilution, but they will not boost overall vehicle selling prices — at least not in the way new product features have in the past. For example, the total price of a Mercedes E-Class automobile with the 2015 digital package is just €1,654 more than the 2010 model, despite the addition of more than €7,000 in connectivity options, most of them substituting previous features that have now become standard. Similarly, BMW spends more than €6,000 per car to include connected-car-style digital features, including the bundling of concierge services and real-time traffic information into its navigation device. Audi and Lexus have similar stories to tell. But overall car prices are not expected to grow materially. In general, competition has kept luxury car prices in the €60,000 to €70,000 range: The average price of an E-Class car rose only about 4 percent, despite all the investments in digital features that auto makers have made. This is expected to continue.

The volume segment, of cars made for middle-income purchasers, also sees auto makers adding basic connectivity functions. Here, digital content is on course to reach 2.6 percent of total selling prices by 2021, up from just 0.5 percent in 2015. However, our research shows that buyers in the volume segment are less willing to spend money on connected features provided by OEMs, despite their appreciation of the importance of digital services (*see Exhibit 1, next page*). Today, they'd rather seek cheaper alternatives from third-party aftermarket makers

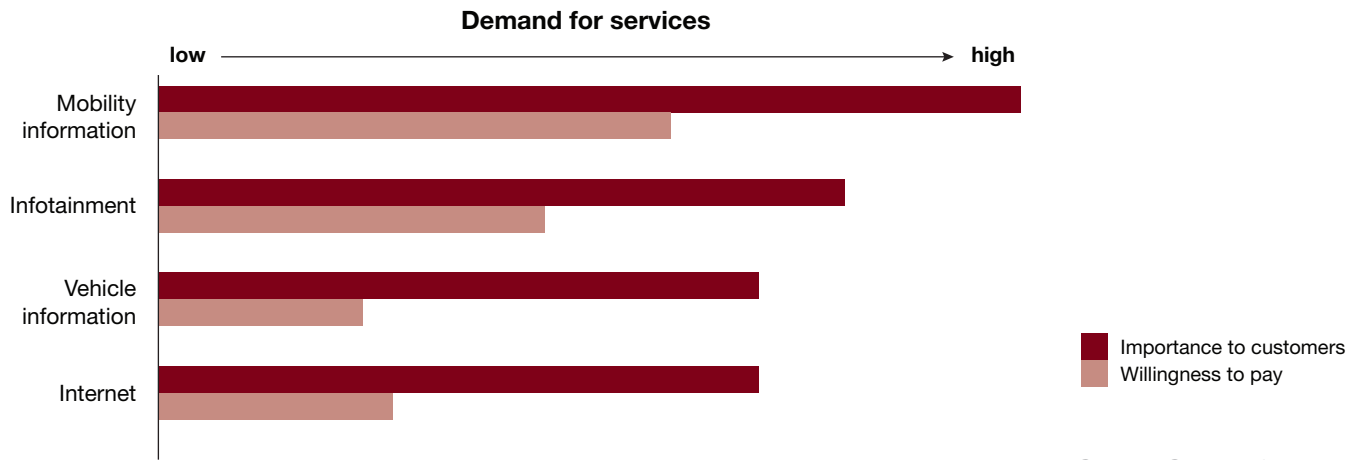
*Buyers in the volume segment are less willing to spend money on connected features.*



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### Exhibit 1

#### Demand for connected-car services among volume car customers



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or from simple apps on their smartphones. To preserve profit margins, mass-market OEMs will have to figure out which digital features their customers will pay for. Volkswagen and other volume OEMs are experimenting with digital packages for value-conscious auto buyers. So far, however, sales penetration rates are low. In the end, consumers may not be willing to pay for proprietary packages; they may choose aftermarket solutions like third-party navigation devices instead. Currently, a TomTom navigation system costs about €180, compared to roughly €600 for a manufacturer's option.

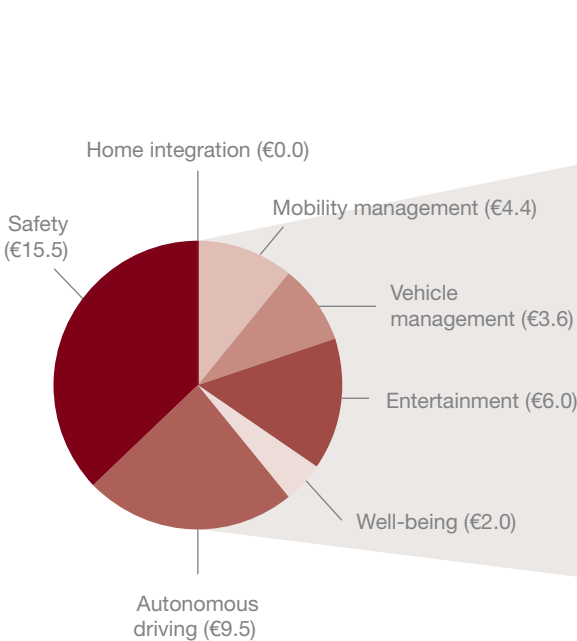
Yet despite all of these factors slowing down growth, we expect overall revenue from digital auto content to grow 204 percent, to €122.6 billion, between 2016 and 2021 (see Exhibit 2, next page). One key catalyst for this is the European Union's mandate that all auto makers implement emergency calling technology (eCall) in new cars by 2018. When there is a collision or other incident, an eCall device in each car will automatically alert authorities and send data about the impact. Although currently smartphones can fill this mission more efficiently than eCall devices, and at a fraction of the cost, customers are demanding that connected car manufacturers incorporate this potentially life-saving technology, and several OEMs have seen success with it, notably GM's OnStar. As eCall technology evolves it will provide a platform for a range of additional digital services.



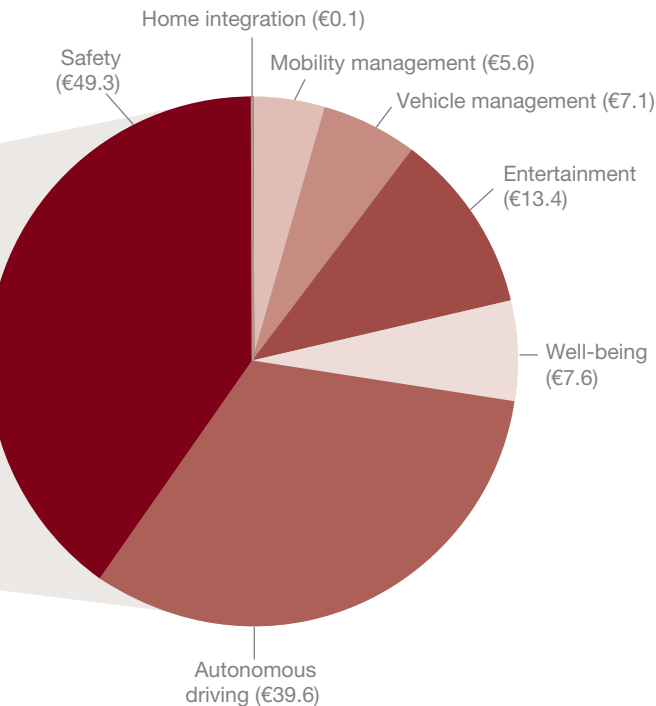
Exhibit 2

Estimated market for connected car technologies, 2016–21

**2016**  
Market potential in billions of euros  
Total: €40.3 billion



**2021**  
Market potential in billions of euros  
Total: €122.6 billion



Note: Totals may not reflect sums due to rounding. Passenger vehicles only, excluding light commercial vehicles.

Source: Strategy&



Other drivers of near-future growth include the increased availability of high-speed wireless networks and cloud-based data services around the world, and the development of application programming interfaces (APIs) needed to create connected car software. On the demand side, growing awareness of digital safety features and entertainment options will spur sales. This, in turn, will encourage investment in connected car services, and give rise to aftermarket demand for connectivity equipment from owners of cars manufactured without digital features.

Our projected growth rate through 2021 slowed a bit from last year's five-year forecast, partly because European regulators pushed back the eCall deadline to 2018 from 2015. Also slowing growth is the OEMs' resistance to connected car technology from industry outsiders. For example, manufacturers aren't allowing Apple CarPlay or Google's Android Auto to serve as primary dashboard interfaces. They require that these options coexist with factory-installed systems; otherwise the manufacturers will block them altogether.



## ***Pricing: A connected car conundrum***

Luxury and volume auto makers alike are still puzzling over pricing strategies for connected car offerings. Current approaches range from a flat fee model to pay-per-use pricing.

Flat fee structures give buyers the use of many digital features, including lifetime services, without additional costs. For OEMs, this approach offers the benefit of a high up-front price for the new technology. But that high price can motivate buyers to look for cheaper options elsewhere. There's also the need for potentially costly technology updates down the road.

A mixed pricing model offers basic connectivity equipment as part of the initial auto purchase. Customers pay a fee to activate services, often after a free trial period. This approach can generate additional post-sale revenues for OEMs, which may share costs with third-party service providers. But post-sale revenues come only if the customer decides to activate digital services.

Under a full pay-per-use model, customers pay periodic subscription fees or charges based on the amount of data they use. The lower up-front costs mean customers are more likely to buy digital services, but OEMs often must share subscription revenues with third-party content providers such as Spotify.



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# *The innovation leaders*

Das Auto Institut, together with Strategy&, compiles annual statistics on connected car innovations at OEMs and Tier 1 suppliers (*see Exhibit 3, next page*). This includes an innovation strength index based on each company's degree of innovative activity, as well as the originality, focus, and maturity level of its innovations. These are divided into two categories: safety-related driver assistance technology (which showed record levels of innovation investment in 2015) and infotainment innovation (where R&D investment matched a 2009 peak). The institute surveys all new innovations in the market and rates them in terms of inventiveness and importance, all of which determines an OEM's innovativeness rating. The stakes are highest for the companies that consistently launch relevant and ground-breaking new features, as the index is cumulative over time.

VW ranked first and Daimler second in both the safety and infotainment categories in both 2014 and 2015. BMW, the leader in connected car infotainment innovations between 2009 and 2012, dropped into fourth place in 2015 behind Ford, in that category, as well as in safety innovations.

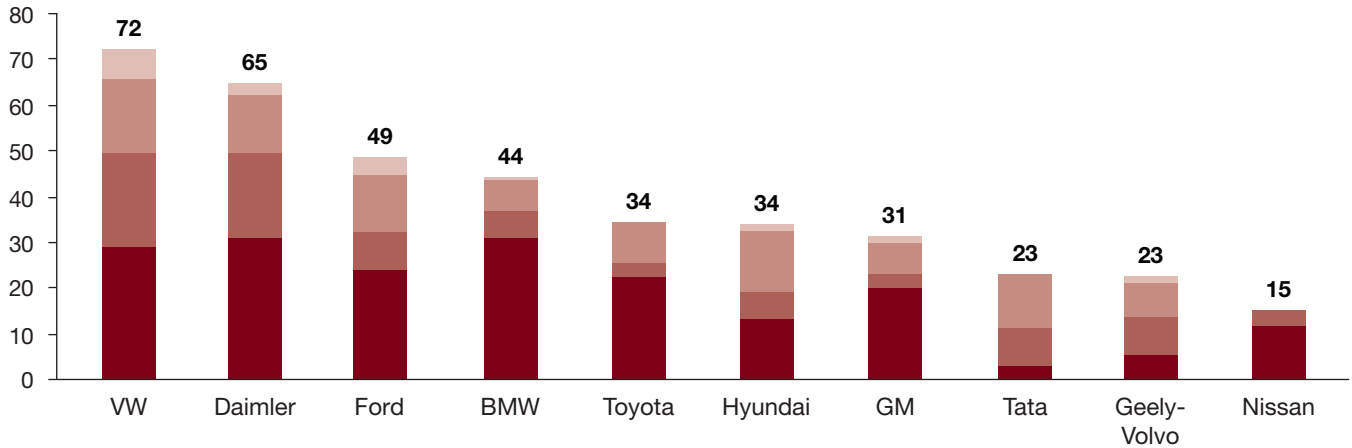
Among Tier 1 suppliers, Bosch was at the top in innovation in 2014, with Continental in second place, followed closely by Visteon. TRW and Valeo were further behind (*see Exhibit 4, page 15*).



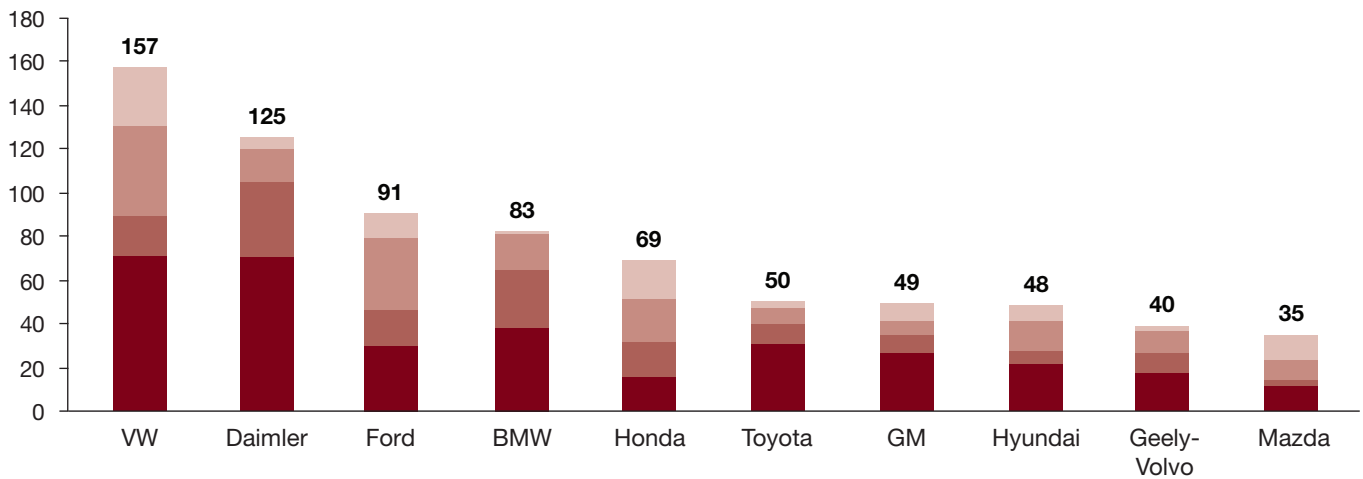
Exhibit 3

Cumulative connected car innovation activity by auto makers, 2009–15

Infotainment



Safety



Addition 2015 (Q1)  
 Addition 2014  
 Addition 2013  
 Cumulated Index 2009–12

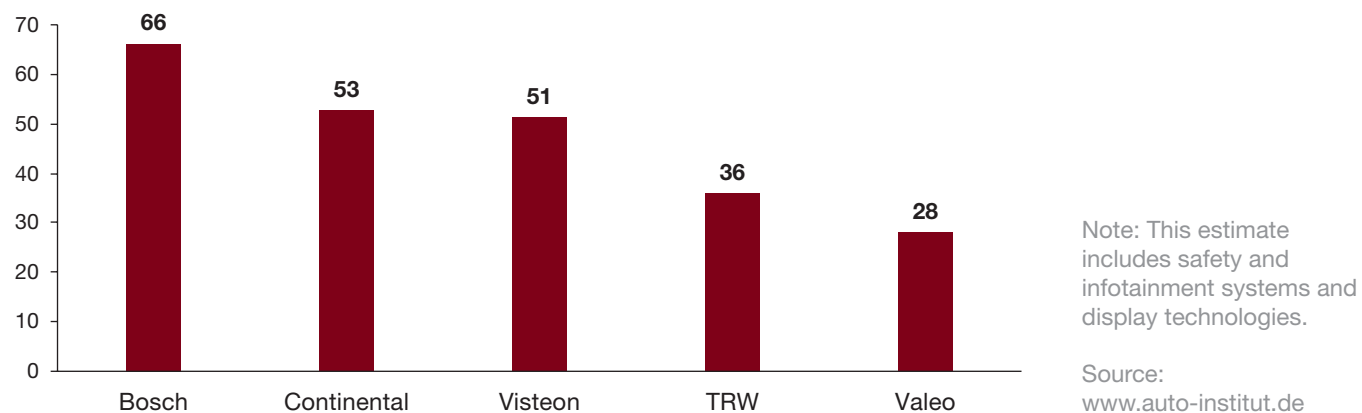
Source: Das Auto Institut  
Index, [www.auto-institut.de](http://www.auto-institut.de)



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*Exhibit 4*

**Connected car innovation activity by suppliers, 2010–14**





## **Potential growth in the seven functional areas of connected car technology**

### **1. Autonomous driving**

Market potential: 33 percent compound annual revenue growth to €39.6 billion in 2021

Trends: This is the fastest-growing connected car feature. Many technologies are developing faster than expected. There is strong demand in China.

Challenges: Unclear legal and regulatory frameworks; liability issues

Key products: Autonomous parking and congestion navigation at low speeds available today; fully autonomous long-range driving at highway speeds expected between 2020 and 2025

### **2. Safety**

Market potential: 27 percent compound annual revenue growth to €49.3 billion by 2021

Trends: Safety is a key selling point for connected cars. China will drive global demand. The roll-out of the eCall emergency calling system in Europe by 2018 will require investment.

Challenges: Limited commercialization potential for safety products as they become standardized and regulated

Key products: Automatic emergency calling to first responders in case of accidents; danger warning systems that alert drivers to roadway hazards, obstacles, and blind spot incursions; collision protection systems that automatically slow car or control steering to prevent accidents

### **3. Entertainment**

Market potential: 18 percent compound annual revenue growth to €13.4 billion by 2021

Trends: Consumers, especially in Asia, consider connected entertainment a basic automotive function. They expect easy, flawless integration of their personal devices, such as smartphones and wearables. Digital development hubs facilitate coordination and integration across industry lines.

Challenges: Lack of standardization processes; struggle over control points; OEMs must adapt to accelerated product development cycles of consumer electronics industry

Key products: Numerous personal entertainment options available today including social media, music, movie downloads, restaurant recommendations; car as a mobile Wi-Fi hotspot; mobile office with access to email, conferencing, and other workplace capabilities

### **4. Well-being**

Market potential: 31 percent compound annual revenue growth to €7.6 billion by 2021

Trends: The growing group of affluent older drivers will pay for technologies that monitor their well-being while driving. There is significant potential to prevent accidents and save lives with systems that detect conditions that impair driving abilities. The underlying technologies are well-developed, setting the stage for product introductions after 2016.



Key products: Fatigue detection systems warn driver when in-car cameras discern signs of drowsiness; well-being assistants change interior temperature, lighting, and other interior factors to enhance driver's condition and driving ability; vital assistants warn driver when vital signs such as heart rate indicate physical distress and trigger emergency braking systems to stop car when driver blacks out

## **5. Vehicle management**

Market potential: 15 percent compound annual revenue growth to €7.1 billion by 2021

Trends: A range of existing technologies can reduce operating costs and increase ease of use for drivers and fleet owners. Demand is driven by rental car companies, car-sharing services, and Internet companies in partnerships with auto manufacturers.

Key products: Smartphone-based remote control of car functions; vehicle tracking and performance monitoring; maintenance monitoring and scheduling; remote software upgrades and recall notification; car usage data tracked and transmitted to insurance companies for usage-based pricing

## **6. Mobility management**

Market potential: 5 percent compound annual revenue growth to €5.6 billion by 2021

Trends: Rising traffic congestion and air pollution, driven by urbanization, are sparking demand for tools that

get vehicles to their destinations more efficiently. The growth potential is greatest in China and the U.S. This feature will allow OEMs to invest in integrated mobility management systems that generate long-term incremental revenue.

Challenges: Need for coordination among automobile, information technology, telecommunications, and petroleum industries.

Key products: Navigation tools plan efficient routes based on real-time traffic information; head-up displays on windshield allow driver to see route plan without taking eyes off road; system recommends optimal speed based on traffic and roadway conditions, shows lowest-priced gas stations along route, finds open parking spaces

## **7. Home integration**

Market potential: 20 percent compound annual revenue growth to €66 million by 2021

Trends: As the Internet of Things connects more household appliances and systems to the Web, consumers are embracing home automation, which in turn will drive demand for integration of these systems with the car.

Key products: Integration tools allow driver to control home and building functions such as heating and cooling and security systems; connection between vehicle and home infrastructure for safety, mobility management, comfort, and entertainment functions; home energy package with e-vehicle as energy storage system



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# ***The promise of autonomous driving***

The connected car is more than a new package of automotive technology features. It's a disruptive technology that will upend traditional auto industry structures, usher in new business models, and change the nature of the business. The automobile is rapidly becoming a "thing" in the Internet of Things: the interconnection of computers, smartphones, sensors, actuators, and many other intelligent devices. By 2020, an estimated 50 billion devices are expected to be connected to the Internet, 10 times the installed base of personal computers.

Already, most new cars are equipped with sensors and connected to high-speed wireless networks. They transmit streams of valuable data and facilitate a wide range of digital services. Over time, these services will come to define the automotive value proposition. The German auto industry alone is expected to pump €11 billion annually into digitization and Internet of Things investments by 2020, and R&D spending for 2015 has already surpassed planned budgets by 40 percent, thanks to pressure to innovate in both legacy and digital areas. As the digital content of automotive innovation rises over the next few years, however, returns on R&D spending for non-digital components will shrink (*see Exhibit 5, next page*). There will be diminishing returns on innovation investment in legacy features, such as the chassis or engine.

We expect the shift to autonomous driving to begin in earnest before 2020, with 20 percent of new cars sold likely to have significant autonomous capabilities by 2025. Piloted driving will start in urban areas. At first, autonomous driving will not be fully autonomous. Although digital players are looking at radical innovations such as self-driving cars without steering wheels, for OEM manufacturers the autonomous car will be seen as a bundle of driver-assistance features — from "passive" features such as the parking assistance systems available today, to semi-autonomous systems that allow drivers to take control at any time. Yet the advances will be steady, and by 2030, we may see fully autonomous vehicles that may not even have steering wheels. Even the slower plausible scenarios show 15 to 20 percent penetration by autonomous vehicles in 2030, only 15 years from now (*see Exhibit 6, page 20*).

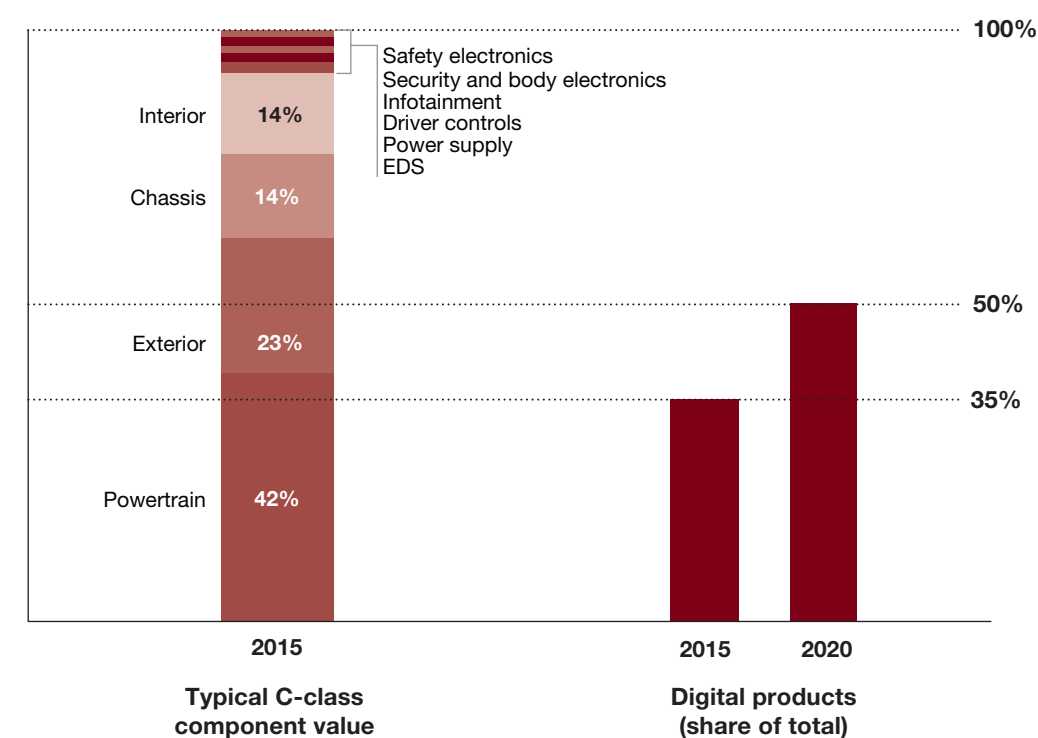
*The connected car is a disruptive technology that will upend traditional auto industry structures, usher in new business models, and change the nature of the business.*



Exhibit 5

# Share of digital content and its impact on revenues

Value of digital products will increase from 35% to 50% of new premium cars



Connected car revenues will surpass 10% of new premium car value

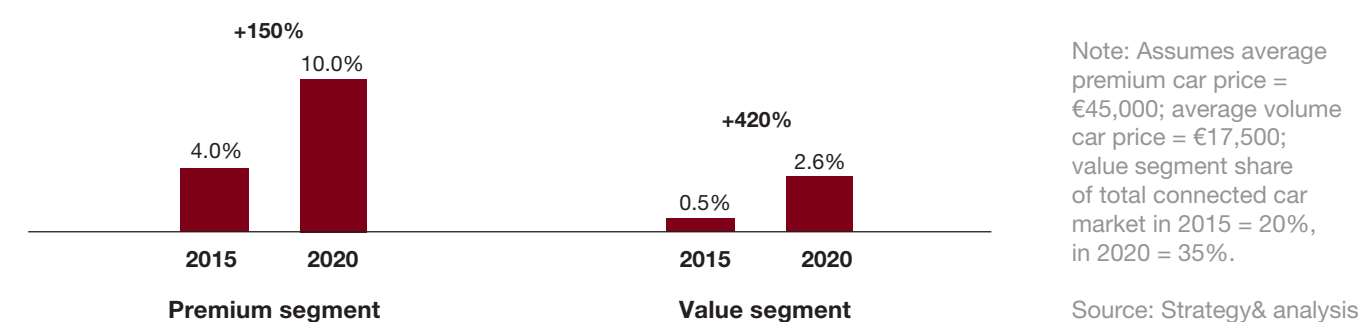
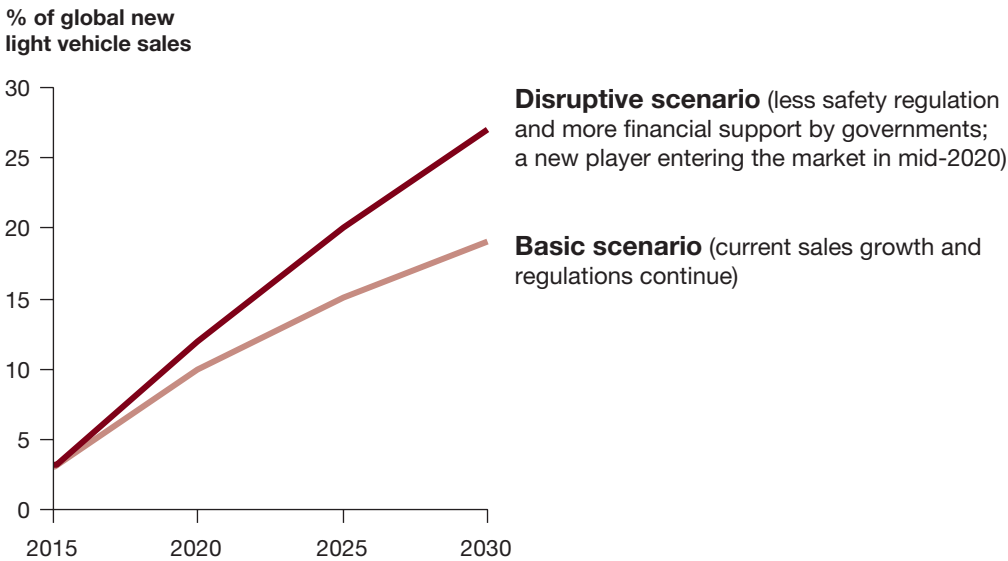




Exhibit 6

Scenarios for the penetration of autonomous vehicles



Note: Figures reflect semi-autonomous and fully autonomous vehicles only, not other connected-car features.

Source: IHS; Internet research; Strategy& analysis



Skeptics who doubt the impact of autonomous driving may be convinced by the impact it has on the traveling experience. Freed of the need to keep their hands on the wheel and their eyes on the road at all times, people can turn their attention to other activities as they travel along the highway. They will watch movies, shop, engage in social communication, or conduct virtual conferences.

Most significantly for auto makers, auto buyers will come to regard the car as a bundle of services, rather than a package of hardware. The autonomous vehicle represents a value proposition, especially in urban areas, that is significantly different from the driving pleasure and automotive identity sold by today's auto makers. Many consumers will still want to own their own cars, but they will increasingly favor convenience, digital services, and ability to upgrade over performance and perhaps over durability.

Autonomous cars have the potential to transform mobility. Shared-car services like Uber and Lyft are harbingers of this transformation, building an audience that is accustomed to purchasing mobility as a service rather than owning the means of transportation. Many cars will be dedicated to travelling specific routes, as is happening with Heathrow Airport's "parking pods," autonomous vehicles that carry passengers from the parking lot to their terminals. Some cars will evolve to handle particular purposes, showing up at the door to carry people on vacation. Others will be used by commuters, replacing both the commuting automobile and the bus, for example, with coordinated routes organized through algorithms, enabling people to share rides with far more convenience and comfort than is available today. Mobility in many major cities of the world will need to be cross-modal, however, combining the infrastructure for autonomous cars with facilities for walking, bicycling, and public transportation.

According to the *Economist*, automobiles are among the most expensive investments people make, but they sit idle 96 percent of the time. As it evolves, the connected autonomous car will improve that number. Mobility-as-a-service reduces the number of cars and the congestion on the road, along with the number of parking spaces required for transportation. It will encourage cars that look different from the automobiles of 2015; it will challenge the way people think about cars in the first place.

Autonomous vehicle technology will also transform the transportation of goods and the use of heavy machinery. The costs for setting up a truck to be guided by sensors, GPS, radar, and software has come down from about €180,000 for the early prototypes to just a few thousand euros, and these equipped vehicles would dramatically reduce such standard costs as insurance premiums. They would increase fuel

*Auto buyers will come to regard the car as a bundle of services, rather than a package of hardware.*



efficiency by 15 to 20 percent and potentially increase productivity by just as much, especially because trucks could travel around the clock and their shipments could be organized accordingly. Highways could become less congested, especially if long-distance goods-transportation lanes are created on heavily travelled routes. The challenges are great, but as it moves from closed-loop systems (like those used to transport ore in mining operations), the connected truck could become the rule, rather than the exception, in transportation logistics.

During the early phase of autonomous auto development, from 2015 through 2020, we expect to see a number of auto makers follow through on their announced concept-car-style innovations (*see Exhibit 7, next page*). This will be a time of opportunity for many players, as the changing nature of driving creates rich new digital revenue streams. The shift to mobility-as-a-service will disrupt automotive value chains, creating entry points for new rivals. Competition will come from newcomers like tech giants Apple and Google, and from traditional allies like Tier 1 automotive suppliers. The pressure of disruption will be felt not just by auto makers, but also by their auxiliary industries: suppliers, dealer networks, aftersales providers, car financing providers, used car dealers, taxis, and mass transit systems. Companies in each of these sectors should begin to prepare for this change, and to find ways to step out in front and lead.

Rather than merely defending their share of vehicle selling prices, successful OEMs and Tier 1s will capitalize on connected car technology as a portal into adjacent service markets. As autonomous driving evolves, they'll tap into new revenue streams. We estimate these opportunities to represent €3,300 per year per household globally in the premium segment alone.

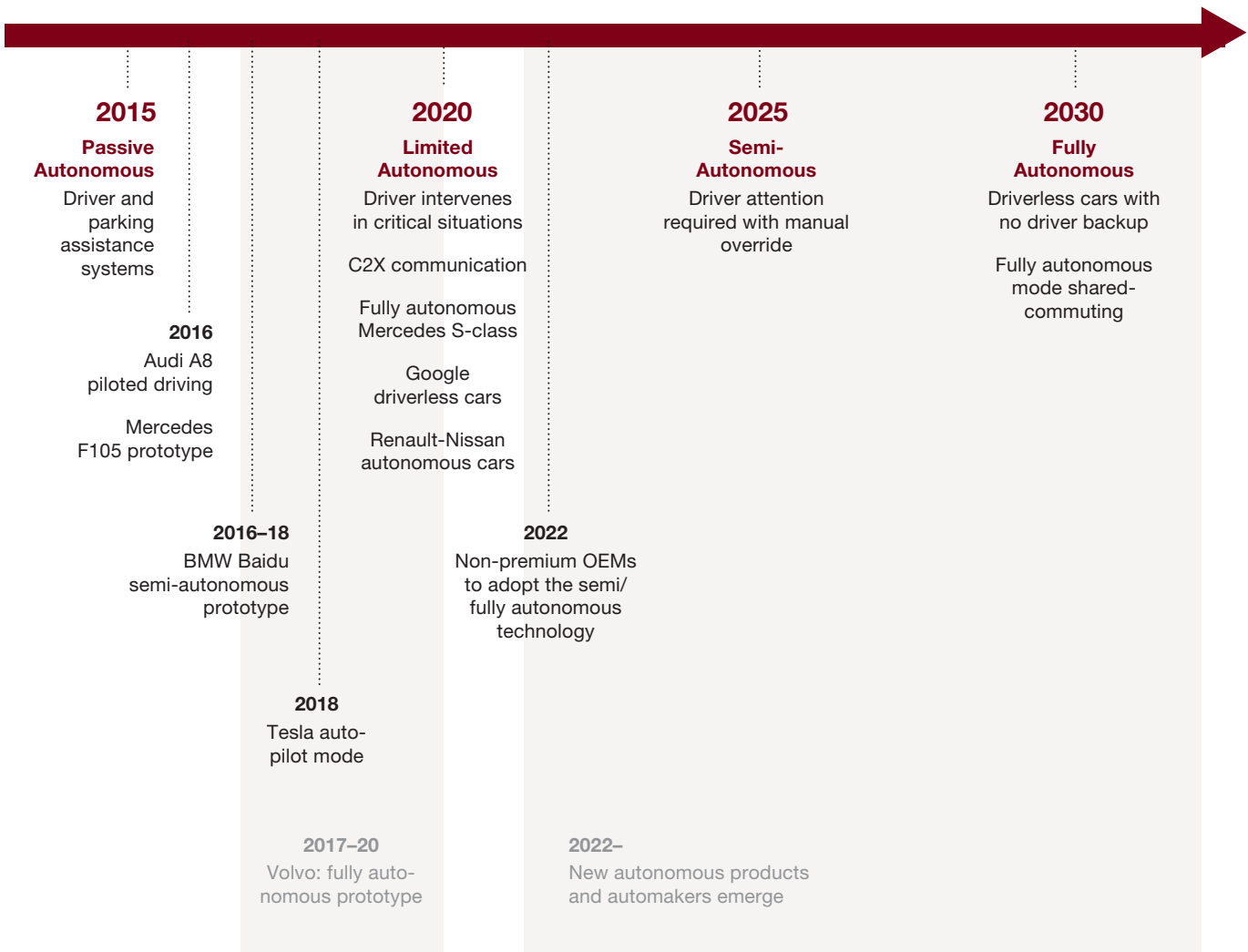
The largest portion, some €2,400, is in mobility. As consumers come to see transportation as a service, more will decide they don't even want to own a car. Already, many are opting instead for short-term rentals and car-sharing services that allow them to choose the vehicle that best suits their needs for each different driving occasion.

OEMs and others responding to this shift will offer mobility as a service, creating subscription models under which customers pay a monthly or yearly subscription fee for access to a range of vehicles that meet various transportation needs. For business trips, the customer might choose a limo equipped for virtual conferencing, immersive virtual reality collaboration, and other office functions. Family vacations might call for a roomy vehicle with sophisticated entertainment kit and services.

*Already, many consumers are opting for short-term rentals and car-sharing services that allow them to choose the vehicle that best suits their needs for each driving occasion.*



Exhibit 7  
Possible time line of autonomous car innovation



Source: Internet research;  
IHS; Strategy& analysis



Although OEMs have a natural right-to-play in mobility services, they should also tap other potential digital service markets. We estimate that €990 per household per year is available for services related to entertainment, housing, healthcare, and a host of other industries, all of which can be linked to the automobile. Playing in these services will deeply challenge existing capabilities, but it may be a necessary move for OEMs to preserve relevance in the eyes of their customers.

To thrive in this business, auto makers and suppliers must learn to compete with new players, including technology companies native to the digital realm. Apple and Google are already chasing automotive revenues not only in infotainment, but also in basic autonomous driving technology. Google has raced ahead with technology that could become a standard operating system for self-driving cars, similar to its Android system for mobile communications.

Technology companies and auto makers operate with profoundly different principles and this colors their perspectives on autonomous vehicles. Auto makers have a product manufacturer's point of view. They see autonomous driving technology as an add-on to existing platforms. Tech players, by contrast, see the connected car as a greenfield opportunity, with autonomous driving as the starting point. They're creating new offerings from scratch, from an Internet-based, service-oriented perspective.

Auto makers favor proprietary technology tightly linked to hardware, emphasizing reliability and regulatory compliance. Their development cycles are long and their closed systems don't interact well with outside technology. Technology firms are less concerned about legacy systems. They value speed-to-market, versatility, rapid product development, and frequent iteration. Many operate on open platforms with standard protocols that can be used by a wide range of players. Their products show keen understanding of consumer needs, but can fall short in reliability and durability.

The ultimate winners will combine the best of both perspectives. They will get to market early with digital offerings that meet customer expectations, while building the scale to dominate markets. They'll also create new business models capable of delivering both timely innovations and healthy investment returns.

Competition in autonomous auto markets will unfold along three main fronts:

- Auto makers and Tier 1 suppliers will test tech players' strength in data-based businesses. They'll offer their own digital services in areas such as mobility management, entertainment, and smart-

*To thrive in this business, auto makers and suppliers must learn to compete with new players, including technology companies.*



home technology. An early example is Tier 1 supplier Robert Bosch's partnership with navigation service provider TomTom. Another is the acquisition of Nokia's digital mapping service by a group of high-end auto makers for €2.8 billion. This bolsters their ability to compete with Google. The Mercedes entry into telematics-based fleet management services is a third example.

- Technology firms will move to control critical digital platforms within the connected car, such as sensor data. IBM, for example, has joined forces with Tier 1 supplier Continental to develop technology systems for autonomous vehicles. Uber has begun offering mobility-as-a-service, while Google's well-publicized self-driving car rolls ahead.
- National and local governments will play a role in shaping competition. They'll tilt the playing field by supporting "local champions," as Gothenburg, Sweden, has done for Volvo. And they'll create regulatory and liability structures that advance or impede new technologies. California and Nevada, for example, have enacted laws that favor autonomous cars. China's largest telecom company, meanwhile, is building out 4G networks in part to accelerate the development of connected cars.



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# ***Four “ways to play” in this market***

Rivals in autonomous vehicle technology and services will craft strategies based on their own distinctive competitive strengths, targeting sub-markets where those capabilities create maximum advantage. Although each contender’s strategy will be unique, we foresee four complementary business models emerging across the sector. Some large players may pursue more than one at the same time.

## ***Aggregator of data and audiences***

Some will position themselves to collect and distribute data from connected cars that will have value for third parties that are interested in the behavior of drivers and/or the performance of vehicles. Insurance companies, for example, are likely to pay for information on driving habits gleaned from sensors in cars. Aggregators also will profit from their control of access to large numbers of drivers, which enables them to offer big audiences to advertisers and others.

Scale is the key to success for this way to play — insurers will want mountains of data and advertisers millions of eyeballs. Technology companies have the global scale, technology capabilities, and open systems needed to win as aggregators. OEMs don’t have enough vehicles — let alone connected cars — on the roads to compete with Amazon, Google, and Apple on sheer audience size. Still, auto makers can succeed as aggregators by forming partnerships and capitalizing on their access to exclusive niche audiences such as luxury car owners.

OEMs have another critical advantage: control of primary data from the car. Aggregators need to control access to connected car data such as vehicle location and sensor information, as well as digital gathering points such as search engines and social media.



### ***Digital service provider***

Many players will offer digital services through connected car technology, ranging from entertainment to mobility management and health monitoring. Digital services will be a highly fragmented market where competitors from numerous industries converge. Just about anybody can play, but winners will be those that shape service offerings to the needs of mobile customers and provide the best user experience. Exclusive, high-quality products and platforms will be key differentiators. Digital service providers that have previous billing relationships with customers will control a critical access point to these markets. OEMs will also need to try their hand at developing proprietary entertainment and infotainment in order to remain relevant in the digital services industry. A role in that end of the business will also help them develop analytics about their own customers.

### ***Digital augmented product provider***

Many OEMs will capitalize on their automotive expertise and customer insights to help optimize the performance and utility of vehicles. They'll offer a range of digital services such as fleet management, predictive maintenance, and automated driving to operators of large vehicle fleets. This way to play requires exclusive control of vehicle sensor data, billing relationships with customers, secure navigation data, and access to the artificial intelligence engines in autonomous vehicles.

### ***Digital enabler***

Some competitors will carve out niches as suppliers of high-value digital components of connected car infrastructure. These specialty players are likely to target a single product, such as street-monitoring sensors that tell an autonomous car whether roadways are clear. Their goal is to be the dominant supplier of a component to all OEMs. They'll play on multiple levels, as both suppliers to and competitors of other providers of connected car products and services. Control of technology through patents and standards is critical to their success.

All four value propositions will require auto makers to redefine themselves as service providers. They will thus need new operating models, capabilities, and cultural mind-sets. A go-to-market model based on efficient production and distribution of hardware won't meet the needs of customers who value digital services over physical characteristics like horsepower and handling.



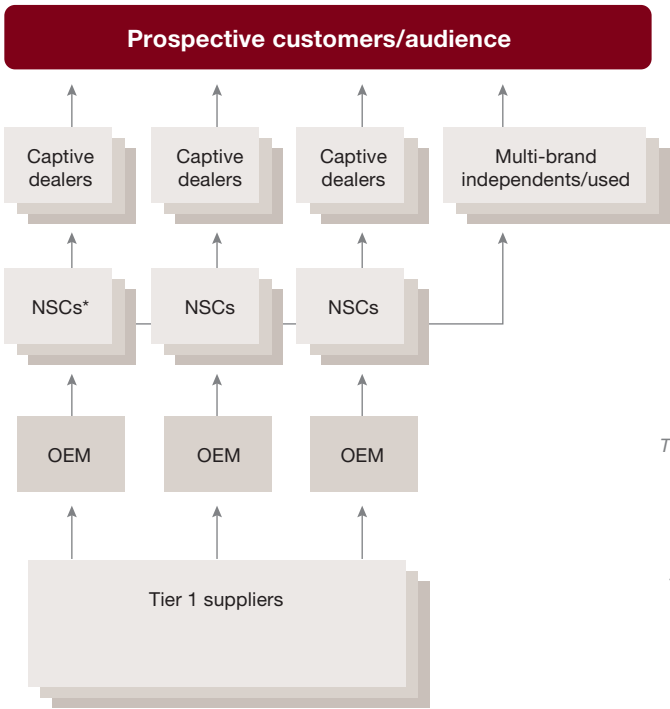
The industry structure will also have to change. Today, Tier 1 companies design and supply components under the direction of OEMs, which assemble and ship cars to dealers, which sell them to the public. It's a controlled, closed ecosystem focused on physical products and a retail-sales mentality. A new automotive ecosystem will arise that's more open, multilayered, and focused on digital services over physical products. We will see decreased retailing of new and used cars as the auto sales industry begins to blur with auto rental and sharing. We will also see more cross-brand platforms and collaboration. Roles will blur up and down the value chain and new entrants will play key parts in bringing autonomous vehicles to market (*see Exhibit 8, next page*).

Finally, the autonomous vehicle raises major questions about liability that need to be resolved. If, despite all the safety features imaginable, there is still an accident, who is to blame? Who will be held legally responsible? Is it the OEM? The road infrastructure provider? The software provider? The telco that transmits messages? The passenger? The navigation provider? Or a combination of all of them? With the threat of cybersecurity challenges, as we'll see in the next section, this unresolved issue becomes all the more important.

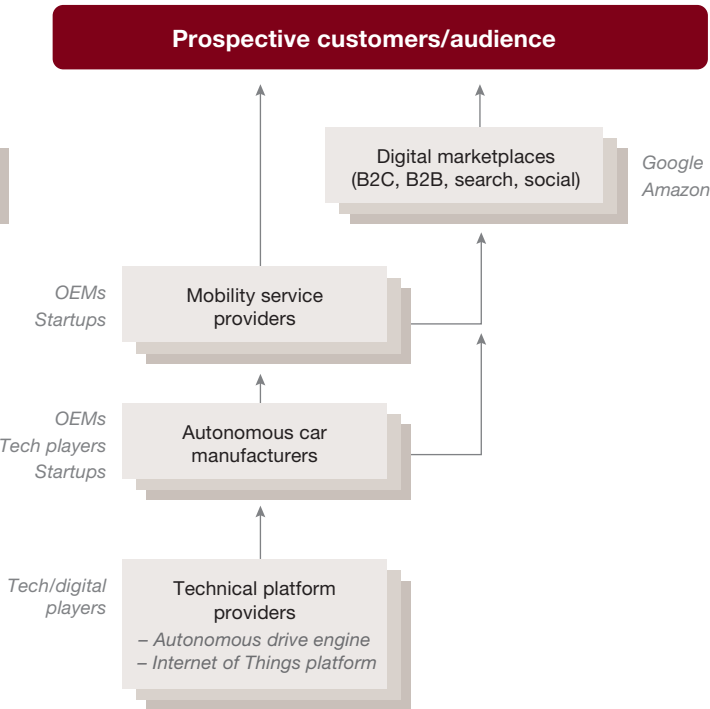


Exhibit 8  
Automotive industry structures, today and tomorrow

2015 industry structure



2025 industry structure



\*National sales companies

Source: Strategy&



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# *The cybersecurity challenge*

For all of its promise as a source of new revenue for auto makers, the connected car also presents unprecedented hazards. Widely reported recent incidents have focused public attention on the vulnerability of digitally connected autos to electronic malice.

A controlled hack reported by *Wired* magazine stopped a Jeep on a highway. Security researchers who hijacked a Tesla's onboard systems cut power to the car, disengaged its powertrain, and manipulated doors and windows. Another group of researchers slipped into BMW's Connected Drive system and opened a locked car from afar.

These events highlight the unsettling reality: every breakthrough in digital automotive technology comes with a security risk. Connected car features — although they deliver new services, improve the driving experience, and make production more efficient — attract online miscreants of various stripes.

Because they endanger drivers, security risks are an existential threat to the reputation and finances of auto makers. Hackers who infiltrate the car network can enable digital features without paying, or bill customers for services they didn't order. Chip tuners will try to manipulate engine values through the CAN Bus interface to increase motor power. Criminals could steal cars remotely by disabling the immobilizer and ordering the vehicle to drive away. The synchronization of consumers' mobile devices with car systems puts their personal data at risk of remote theft by a hacker who has compromised the vehicle's Bluetooth or Wi-Fi interface.

Hackers attacking through back-end, maintenance, or third-party systems could manipulate car sensors, engine controls, and other vehicle functions. Doors can be locked, brakes can be disabled, or the engine revved to full speed. Production systems that deliver electronic features over the Internet can be used by dishonest car buyers to get options they didn't pay for. Most troubling of all is the possibility that terrorists could hack into autonomous driving systems and cause accidents that kill a targeted individual or large numbers of people.

*Every  
breakthrough  
in digital  
automotive  
technology  
comes with a  
security risk.*



These threats undermine customer trust, a key success factor for auto makers in the digital era. Consumers will steer clear of connected cars if they believe new technologies put their personal information and safety at risk. Thus, to realize the vast potential of digital automotive technology, auto makers must convince consumers they will be safe and secure in vehicles hitched to open electronic networks.

An effective automotive cybersecurity strategy is the only way to provide the assurances customers want. It is our view that the responsibility for security will ultimately fall to the OEMs. As service providers, OEMs will need to build trust in their security systems; those that do will capture the digital prize, while those seen as vulnerable to hacking will lag behind.



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# *The architecture of security*

An effective cybersecurity strategy starts with an understanding of how digitization and the Internet have changed the IT infrastructure of the auto industry and its supply chain. Auto makers have long considered IT as a collection of independent systems. Back-office systems process and manage data, support operations, and handle transactions. Production IT runs factories and other aspects of supply and distribution. In-car systems control vehicle operations and connect the car to the Internet, mobile phone networks, and digital service providers.

When industry executives think about information security, they usually focus on in-car systems as the point of vulnerability. But threats extend well beyond the dashboard interface. The Internet has connected all three areas of automotive IT into an integrated whole. Hackers who get into one area — say, through the CAN Bus that is in many cars — can do damage elsewhere by bypassing authentications, firewalls, and other security measures. With enough persistence and skill, they can gain access to apps with banking or credit information; they can track the location of a vehicle as it travels; and they can use this information for theft, espionage, extortion, or control of the vehicle. Some criminal hackers try to steal or modify cars; others sell stolen data. A few are terrorists with lethal aims.

They may not need physical access to in-car systems to achieve their goals. The BMW hack showed that outsiders can commandeer a car through an auto maker's back-end systems, without ever touching the vehicle.

Cybersecurity is thus more than a technical challenge for IT staffers to tackle. Auto makers can't view IT as an isolated function. Effective security strategies approach IT as a single, interconnected architecture with multiple vectors for intruders, from Bluetooth systems to Wi-Fi connections and various back-end interfaces. OEMs must bring all these systems together under a comprehensive security umbrella, spanning the value chain from C-suite to factory floor, R&D, and the entire ecosystem of suppliers.

*The Internet has connected all three areas of automotive IT into an integrated whole.*



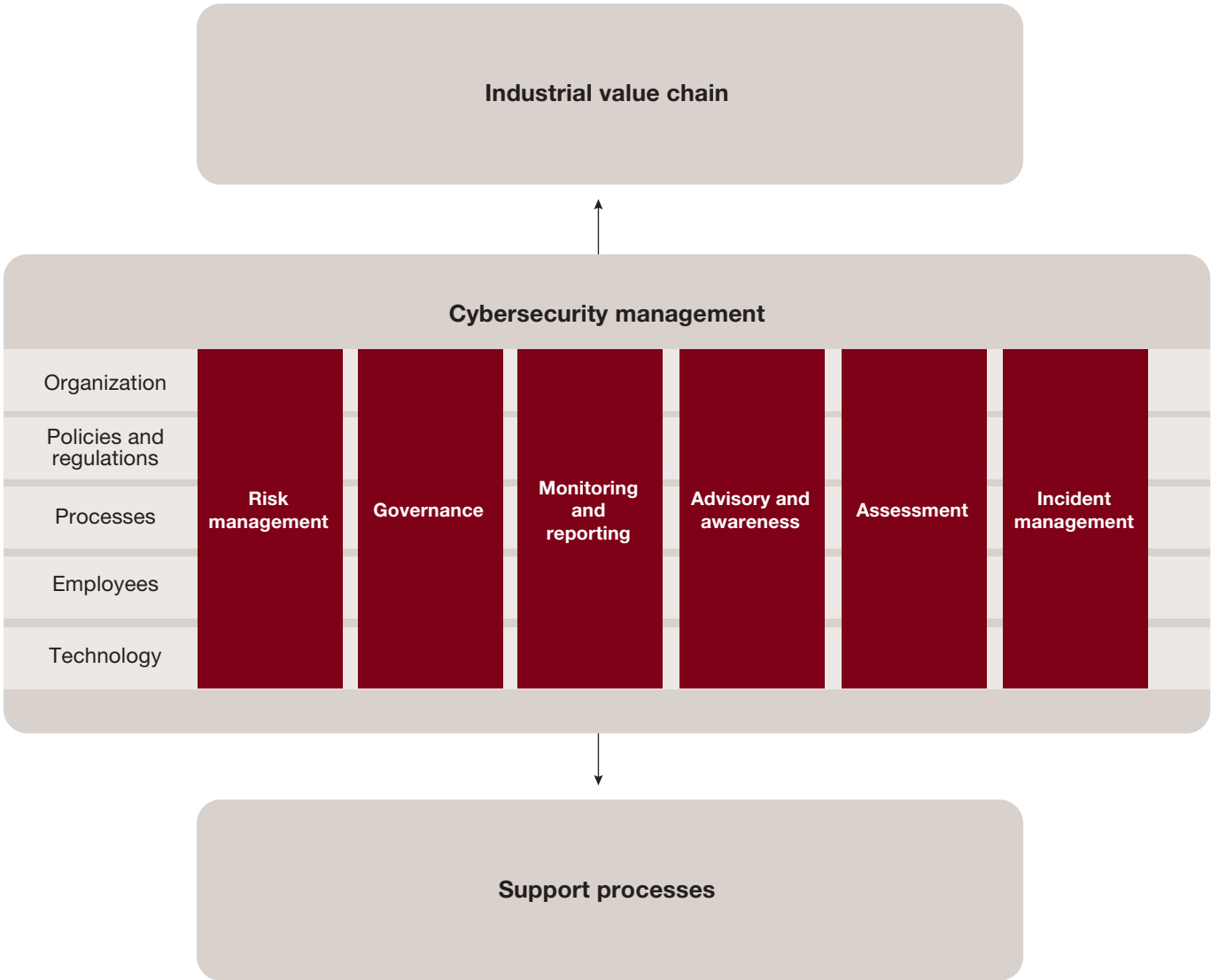
As auto makers work to counter threats, they should address information security early in the product development process. Tier 1 suppliers also will have to embed security measures in their operations. Even third parties that bill customers for various digital services will take steps to control confidential personal information in their systems. Internally, OEMs will need risk management systems to identify and quantify threats, as well as policies and procedures for securing data and systems against intrusion. Equally important are rigorous monitoring and reporting systems to assure the effectiveness of security measures, and detect and call attention to weaknesses in the system. Advisory and awareness mechanisms must be in place to make security concerns known to the right decision makers.

Employees throughout the company must be trained to recognize security risks, and schooled in best practices for protecting information, as well as Secure Development Life Cycle. Manufacturing, logistics, and other operations functions have important roles to play, as do support services such as purchasing, business development, and planning. Incentives and job descriptions should reflect the importance of their responsibilities in this area.

Together, these measures form an overarching “Information Safety Management System” that develops security strategy, assigns responsibility for various security roles, allocates resources as needed, coordinates initiatives, monitors performance, responds to threats, and continuously improves security measures (*see Exhibit 9, next page*).



Exhibit 9  
Components of an automotive company’s cybersecurity system



Source: Strategy&



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# *The auto maker's response*

Is the auto industry facing the same kind of digital disruption that reshaped personal computing and telecommunications? Consider the parallels. About 20 years ago, Microsoft dominated computing as a powerful platform business presiding over a hierarchical ecosystem of suppliers tethered to its technology. Intelligence was embedded in products manufactured and distributed to retailers by PC makers such as Hewlett-Packard, Dell, and Fujitsu. Customer service was generally poor. A huge supply base of components and accessories supported the industry. The bill of materials represented about 99 percent of PC selling prices.

Today Microsoft and other leaders of the PC era are scrambling to find their place. Intelligence has shifted to the cloud, smartphones and other devices have supplanted the PC, and online retailing has enabled direct-to-consumer distribution. A new wave of improved interfaces, pioneered by Apple and adapted or adopted by others, have changed consumer behavior. Those that did not join this movement are no longer thriving.

It's not hard to imagine a scenario in which digital connectivity undermines auto makers as it did Microsoft. We already know that technology players will create digital platforms for manufacturers that provide vehicles to mobility service providers. Autonomous vehicles will be marketed through a range of digital marketplaces, using search, social media, B2B, and B2C channels. Some companies will market cars directly online, as Tesla does today. Even if dealers retain a role in vehicle distribution, the digital services that will account for most of the industry's future growth can be marketed directly to customers over the Internet. The most prominent auto makers and Tier 1 suppliers have advantages that may spare them the fate of once-dominant telcos and PC stalwarts. But they ignore the lessons of those industries at their peril.

To respond effectively — and to lead, as they will have to do — traditional auto makers will need many digital capabilities. These will include digital sales and marketing, omnichannel customer engagement, and the ability to package and deliver digital products

*Auto makers and Tier 1 suppliers ignore the lessons of once-dominant telcos and PC stalwarts at their peril.*



and services. In the operations sphere, they'll need data and content management skills, along with the ability to manage digital infrastructure, protect customer identities, secure information systems, and manage service-oriented technology, while overseeing a digital operating model and numerous outside partnerships. To hold their own in the Internet of Things, auto makers will need to manage sensors and connected devices, create mobile-to-mobile services, and analyze reams of data generated by autonomous vehicles.

They will need to migrate their cultures to this new world. Traditional automotive industry cultures are supply-driven — companies push products into markets and try to persuade people to buy them. They spend billions each year on ad campaigns trying to drive consumer choices. Digital company cultures, by contrast, respond to customer demand, making the products people want. Spotify, for example, gives customers the music they request. On advertising, it spends a small fraction of what most auto makers spend.

Organizationally, auto makers have analog cultures. They accept the slower decision making that comes with multiple layers of hierarchical management. Process is paramount and barriers to progress rarely challenged. Employees are valued for their stability and “institutional knowledge.” They follow pre-defined career paths and work in homogeneous, siloed teams. All of this reflects an industry that moves in predictable cycles and hasn't changed much over the past century.

Tech companies have digital cultures, with flat hierarchies that speed up decision making. Emphasizing results over process, they empower workers to innovate, knock down barriers, and do whatever it takes to achieve goals. They prize workers with vision, curiosity, flexibility, and motivation. Collaboration is critical, with mixed teams from various functional specialties working together on projects. Career progression is rapid and unpredictable. This reflects the dynamic tech industry, where change is rapid and unpredictable, innovation essential to survival, and quick action critical to victory.

For premium OEMs, there are several strategies to consider. Define a space to dominate: a type of car that no one else can produce as well as you can. Become a “supercompetitor” in this space: the master of this offering, so much so that other companies must work with you or they won't succeed. Build the capabilities to create this type of vehicle at global scale, even if it means selling under other brands (so long as you control the arrangement). Try a variety of digital ventures that can unlock data value. Move from a transaction-based business model, selling cars, to a service-led setup in which your customers become customers for life.

*Organizationally, auto makers have analog cultures, whereas tech companies have digital cultures.*



For volume auto makers, you will also need to find a viable economic equation: a way to offer the right digital features to the right customers in a way that integrates you into this new world with affordable prices. Share the R&D burden with other companies through smart cooperatives. Try your own digital ventures, on your own or in partnership, to unlock data value. Be selective in your innovation; use your R&D spending as wisely and productively as possible. Find ways to remove bureaucratic blocks so you can unleash creativity and practice frugality at the same time. Shape and support mobility ecosystems; design cars for the shared-vehicle drivers of today and the driverless passengers of tomorrow.

Digital natives entering the automotive field have more of a challenge than they may realize. You will have to pick your play: accommodating the existing industry or disrupting it. Build on your strengths in scale, agility, and software. Seek out the highest-leverage places where connected cars will make a difference (for example, in taxis) and occupy those points. Reimagine mobility-as-a-service in ways that no one else can. And work on getting the legal frameworks to open up to your innovations.

Tier 1 suppliers will have to choose between working with OEMs or supplying to digital natives — the technology may not be robust enough to allow both. Revisit your relationships with the auto makers of your past; help them reinvent themselves. Move from hardware to service-led setups. And initiate your own digital transformation so you can become a true catalyst for the industry at large — and charge premium prices as part of that.

At the same time, the objective is not necessarily to be the company with the most cutting-edge connected car. Those that are first to bring this technology to the market will need to balance their own R&D with cooperation- and platform-based innovation to avoid the “winner’s curse” of ultimately losing out to competitors that improve upon the technology. Apple has rarely been the first to innovate, but has a record of success in scaling up technology that others have originated. Being best rather than first is critically important when the technology centers on a vehicle that carries people and puts their lives at stake.

Connected cars are the leading edge of disruptive technology that’s changing not only the automobile, but the nature of the automotive industry. As connectivity paves the way for autonomous driving, digital content and services have become the industry’s primary source of growth. These services create new opportunities for auto makers, but also for technology companies such as Google and Apple. To succeed, auto makers must not only shift more investments to digital content, but also change their business models, build new capabilities, and drive

*Connected cars are changing not only the automobile, but the nature of the automotive industry.*



cultural change through their organizations. More fundamentally, OEMs oriented to their traditional role as product manufacturers must embrace a new identity as service providers. Those that can make this shift — while providing the security assurances consumers demand — will flourish in the digital era.



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# *About the study*

The market volume projections in this study are based on the IHS Light Vehicle Sales Forecast, and analysis by Strategy& and Professor Stefan Bratzel of the Center of Automotive Management (CAM). Underlying this analysis are estimates of offer and take rates in each region and year for seven connected car product segments. Individual products within the seven segments were determined using CAM's innovation database, supplemented by additional research.

The innovation strength index is calculated by Professor Bratzel, based on four criteria: degree of innovation, focus, originality, and maturity.



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