How Automakers Can Survive the Self-Driving Era

A.T. Kearney study reveals new insights on who will take the pole position in the $560 billion autonomous driving race.
Executive Summary

Transportation as we know it would be impossible without the quantum leaps in technology that have taken place over the past centuries. It is undeniable that the next big thing will be autonomous driving. With this wave of innovation, traditional players in the automotive industry could wind up in the passenger seat, with new entrants sitting pretty behind the wheel.

For original equipment manufacturers to survive in this market, there are five key questions to answer:

1. How can OEMs match consumer needs with autonomous driving solutions, while overcoming skepticism about relinquishing control of the vehicle?
2. How will the market for autonomous driving develop and what will the associated product roadmaps look like?
3. How will government legislation keep pace with new technologies while also addressing questions of liability?
4. Which business models will win in the new industry?
5. What role will partner and competitor ecosystems play in autonomous driving?

To help answer these questions, A.T. Kearney conducted more than 150 interviews with executives at companies around the world who have a strong motivation to make autonomous driving an affordable reality for consumers and for businesses. Our findings reveal crucial insights along the five key questions:

**Consumer needs**

- The connected consumer prefers an individual lifestyle in a big city environment
- More urbanization results in intermodal mobility; services enabled by mobile devices provide consumers with more flexibility and time
- Car ownership becomes less relevant than car-sharing services and platforms

**Market and product roadmaps**

- Changing consumer behavior causes a paradigm shift toward mobility as a service and a preference for lavish private transportation
- The market for autonomous driving grows to $560 billion by 2035¹
- The main product categories around autonomous driving include mobile apps, special equipment, autonomous cars, mobility services, and infrastructure
- Developed and mature markets, including Asian megacities, spearhead market development and a global rollout

¹ Market estimate is based on new car revenues, hardware upgrades, apps, and other digital features.
Legislation, technology, and liability

- Until 2025, legislation is the main roadblock to autonomous driving
- The most pressing legal issue is accident liability
- Achieving economic savings is the primary reason to drive legislation

Business models

- Autonomous driving threatens the very existence of mid-level automakers as the market develops along three segments: premium, low-cost, and drones
- The industry splits in two—those that manufacture vehicles and those that provide consumer services
- Revenues from pay-per-use services outperform optional equipment revenues from 2025 onward

Partner and competitor ecosystems

- Existing players in the automotive industry collaborate with new entrants to offer value-added services
- Traditional OEMs have the first view on the consumer; the first OEM to build a value-added service network with partners wins the market

In this report, we describe the forces shaping the autonomous driving market and what the market will ultimately look like. We also define the core questions facing incumbent OEMs and offer our recommendations on necessary preparations to compete in this market in terms of product structures, business models, and teams.
A New Era of Mobility Is Upon Us

The next quantum leap in transportation is connected mobility. It combines the movement of people, goods, and information into one elegant, consumer-friendly solution built on technology, services, and stakeholders (see figure 1). Connected mobility—and the self-driving vehicles that will serve it—puts major economies on the cusp of the first significant growth wave of the 21st century. This growth will be unprecedented, with an estimated annual value of around $560 billion by 2035 for the core services around self-driving vehicles.

Self-driving vehicles, also referred to as autonomous driving, have a strong allure for consumers and for companies within and outside the auto industry. These companies are fighting for the pole position, jockeying to figure out how to compete and cooperate to serve consumers in this vast market of seamless opportunities—from cross-channel consumer views and personalized offerings to social media, in-store services, and cross-channel logistics.

Figure 1

**Connected mobility is built on technology, services, and stakeholders**

Note: CRM is customer relationship management. M2M is machine to machine.
We recently conducted more than 150 interviews with industry executives worldwide, all of whom are motivated to make autonomous driving an affordable reality for consumers and for businesses. Their companies offer various levels of expertise. Some companies will create and maintain the infrastructure and the vehicles. Others will capitalize on consumers’ newfound freedom by offering a vast range of connected mobility and communications services.

As autonomous driving becomes a foregone conclusion, the most fascinating questions are what will the market look like? How will driving patterns change in the decades ahead? How will the economics of the massive automotive industry change as a result? We cannot answer these questions without first determining who will win in this market, who will survive, and who will lose. The answers will have dramatic and perhaps even fatal consequences for many of today’s traditional car companies. The answers will also affect investors who must decide where to place their bets.

In this report, we describe the forces shaping the autonomous driving market and define what the market will ultimately look like. We outline the core questions facing incumbent OEMs and offer our recommendations on necessary preparations to compete successfully in this market in terms of consumers, products, and business models. We begin with the benefits to society.

**The societal benefits of autonomous driving**

Imagine a world with fewer accidents, fewer traffic deaths, greater energy efficiency, and lower insurance premiums. This is the world of autonomous driving. It brings mobility to people who lack easy or practical access to driving, such as the elderly and disabled. It also appeals to the lifestyles and virtues embraced by millennials, such as health, entertainment, and mindfulness. By the later stages of innovation, we, in accordance with the industry experts who participated in our interviews, expect the following benefits to be especially powerful:

- Reduce traffic accidents by 70 percent, saving thousands of lives every year
- Lower vehicle service costs by 35 percent, in part because self-driving cars have far fewer mechanical wear-and-tear parts
- Cut energy consumption by 30 percent, not only because of alternative energy sources but also because automobiles can use car-to-car communications to swarm or travel in convoys (platoon driving), thus improving efficiency and traffic flow
- Reduce insurance liability by more than 15 percent as driving becomes much safer and new insurance models emerge

The estimated annual savings for the United States alone is expected to be around $1.3 trillion, as shown in figure 2 on page 5.

Most drivers have already enjoyed the first wave of autonomous driving with features such as navigation systems, in-car entertainment systems, lane-assist technologies, traffic warning systems and sensors, and self-parking cars. In the second wave, Google, Tesla, and Uber are aggressively popularizing the idea of self-driving cars (see sidebar: Google, Tesla, and Uber Are in It to Win It on page 6). Baidu, the owner of China’s largest Internet search engine, says it might introduce an autonomous car in the near future. Apple is in the same discussion with its Titan project, though its plans remain unclear.

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6 Baidu May Introduce Autonomous Car This Year, CEO Says, Bloomberg, 9 March 2015
Over the next 20 years, autonomous driving will be the culmination of decades of research and development by many companies around the world, not just the brainstorm of a few disruptive newcomers. This point comes across early in our study as we interviewed executives from the traditional OEMs, telecom services and infrastructure providers, and the large network of suppliers that supports them.

“Premium OEMs will develop their own intelligent cars,” the chief strategy officer at a major OEM told us. Daimler’s self-driving concept car has four swiveling lounge chairs that allow face-to-face conversations when the car is in automatic mode. The vehicle is often seen cruising the streets of San Francisco to give people a glimpse of what vehicles might look like and how comfortable and seamless connected mobility can be. Another executive spoke of dedicated academies, run by the OEMs, to help train consumers to become comfortable with self-driving vehicles.

The companies on the “connected” side of connected mobility are no less ambitious. “We believe that we will achieve a 10 percent share of the mobility market with drones and commuter vehicles,” a C-level executive at an Internet media company told us. Another executive remarked that “drones will be accepted by people who are not able to drive.”

Both the developers of lounge concept cars and the advocates of commuter vehicles and drones recognize the essence of “connected mobility.” Their solutions mark the first time we will have seamless integration of connectivity and vehicular mobility, with connectivity being the force behind the vehicle instead of speed and power.

Some observers believe connected mobility will create a new form of dependency, as people grow accustomed to satisfying their needs and communication desires from within their self-driving vehicles. If this is true, then first-mover advantage goes to the first company that bundles information density, content access, and mobility into a single compelling package. If one of these companies really does claim 10 to 15 percent of the automotive market, it will be an important and influential player, not a niche company.
Google, Tesla, and Uber Are in It to Win It

Google, Tesla, and Uber have had nothing to do with the traditional automotive industry but they are working hard to excite the public’s imagination about the prospects of self-driving cars. Google, for example, has seized the initiative with plans to take information gathering from the prohibitively expensive frontiers of outer space down to our neighborhood streets. The company, determined to transfer its forerunner and pioneer image to cars, is testing something called Google Chauffeur in its own self-driving car prototypes. Google is confident that fully autonomous driving will be available to consumers between 2017 and 2020.

Not to be outdone, Tesla claims its next-generation electric cars will be 90 percent autonomous, relying on a control system aptly named Autopilot. In February 2015, transportation service provider Uber entered the race, announcing a partnership with the Robotics Institute at Carnegie Mellon University to develop a self-driving car that Uber can use in its fleet. In theory, this could enable Uber to make its own drivers obsolete, not to mention the traditional taxi business as a whole.

A recent study describes the benefits of introducing driverless taxis. Of the many benefits uncovered, one of the biggest is price, finding that driverless taxis can turn a nice profit by charging $1 per mile, or even less depending on the size of the fleet. This makes a driverless taxi very competitive with public transportation, especially versus short intra-city trips or versus park-and-ride commuter trains.

What outsiders such as Google, Tesla, and Uber have defined are the new fault lines between hardware, software, and content in the automotive industry. Indeed, drivers will soon take advantage of augmented reality—using millions of data points from multiple sensors to gain a better perception of their surroundings (see figure). Augmented reality can make anything the driver needs appear more prominently in his or her visual and acoustic field, be it an obstacle, a sign, a path to drive on the road, or even a warning to slow down or brake.

Rapid technological changes have given manufacturers and service providers a unique opportunity to reshape the mobility and transportation industry instead of treating autonomous driving as a bolt-on, linear extension of the existing industry.

Figure
Transfer augmented reality pictures within a millisecond

Source: A.T. Kearney analysis

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3 Inside Google’s Quest to Popularize Self-Driving Cars, Popular Science, 18 September 2013
4 Uber, Carnegie Mellon Announce Strategic Partnership and Creation of Advanced Technologies Center in Pittsburgh, Carnegie Mellon University, 2 February 2015
5 5 reasons self-driving taxis are going to be amazing, Vox, 17 March 2015
The $560 billion question: who will win this race?

It will take up to two decades for fully autonomous driving to emerge. While industry players have already developed or tested many of the technological building blocks, tough and tricky legal challenges remain, including new laws on accident liability, on where self-driving cars may operate, and on who may have a license. Also, new traffic guidelines have to be developed for autopilot and for fully autonomous driving. The incentives to establish the right legal framework are high, and executives in our study are confident this framework will develop, probably with California as the pioneer.

The wake-up call for the automotive industry is that not all incumbent OEMs will get a piece of the market. OEMs face hard questions as they jockey for position—from thinking about their value propositions, which core capabilities they need, and which players they should partner with, to developing business models that offer the best go-to-market strategies and the best chances to win. These decisions are high-stake and urgent.

We expect numerous OEMs to be major forces behind the growth in autonomous driving. Who they are and how well they do will depend on their answers to the most crucial and strategic questions, and how they define the problem and solution of connected mobility. Clearly, given their long legacies and established infrastructures, it is natural for OEMs to seek solutions that integrate a connected lifestyle with existing mobility to realize the dream of a mainstream, self-driving car.

But their headline-grabbing competitors from the Internet world are already defining the problem and solution from the opposite direction. These well-known game changers with names like Google, Apple, and Uber want to integrate mobility with an existing connected lifestyle to realize the dream of a self-driving device. The ultimate device—its size and shape, its comfort level, what it runs on, the materials it is made from—will emerge from their intense focus. Designing self-driving devices tailored to lifestyle desires and needs liberates their thinking. They avoid the trap that autonomous driving must be a series of incremental improvements to cars as we already know them. For example, a Google car at its first stage of autonomous, connected mobility will not travel faster than 25 miles per hour (around 40 kilometers per hour). At this speed, Google does not need to install the crash safety boxes mandated by U.S. law. But Google and other newcomers have plenty more to offer. They will secure consumer dependency with a stream of high-density information in a vehicle that still has a competitive highway speed. Their focus is meeting the basic needs of the new digital driver who wants to be always connected.

In contrast, the incumbent OEMs plan to concentrate on systems and integrative functions. So far, they have been successful with incremental approaches and with bolder ideas such as the lounge car concept. But can this be the best set of future roles and future thinking for these OEMs? Or will the demands of the industry be different? How can OEMs—their CEOs, designers, and product managers—think differently about the lucrative future promised by autonomous driving and make sure they claim their share of it?

No class of companies has a greater stake in autonomous driving than the car companies. Yet these same companies are maintaining an equally large stake in the future of the automotive industry. With a foot in both ponds, is it possible for OEMs to win? There are urgent challenges that go far beyond the heavy and necessary investments already made in research and development.
Incumbent OEMs need to think about how to answer five questions and begin making decisions now:

1. How can OEMs match consumer needs with autonomous driving solutions, while overcoming skepticism about relinquishing control of the vehicle?

2. How will the market for autonomous driving develop and what will the associated product roadmaps look like?

3. How will government legislation keep pace with new technologies while also addressing questions of liability?

4. Which business models will win in the new industry?

5. What role will partner and competitor ecosystems play in autonomous driving?

The challenge for incumbent OEMs is anticipating what that vehicle or mobile device might look like. Let’s start with the premise that companies such as Apple and Google want to preserve the seamless always-on lifestyle and recognize that people often want or need to get from point A to point B. The solution is to take the connected exchange of data and information that underpins that lifestyle and add mobility. If you think in these terms, what kind of vehicle or device do you need? Odds are that the end product isn’t a one- or two-ton metal box that spends more than 95 percent of its time sitting idle.

Markets and Products: Autonomous Driving Is a Lucrative, Game-Changing Opportunity

The markets

How large and lucrative will the autonomous driving market be? We estimate that the annual market just for special equipment—onboard control, guidance, and communication systems—will reach $103 billion by 2030. Mobile apps that facilitate car-to-car telematics and communication between cars and other entities will account for another $86 billion. Fully autonomous vehicles with no manual intervention by the driver will start to appear in the late 2020s, and by 2030, we expect the market for the vehicles alone to reach $95 billion.

The biggest leap over the next decade will be the integration of mobile broadband systems with robotic drive systems. Companies or alliances of companies that first develop a standard will be the winners, and their reward will be revenue and double-digit EBIT growth.\(^6\)

All told, the apps, equipment, and vehicles related to autonomous driving will pull in $282 billion in revenues by 2030, which represents about 7 percent of the total automotive market (see figure 3 on page 9). The numbers get much bigger from there. We expect the market to almost double to around $560 billion between 2030 and 2035 and represent 17 percent of the global automotive market. And this estimate does not even consider ancillary revenues from mobile apps, which will form the basis of many in-car services. By 2030, traffic management systems will free up a mind-blowing 1.9 trillion minutes for passengers, most of whom already have a smartphone within arm’s reach at all times (see figure 4 on page 9). The competition for drivers and passengers will be fierce.

\(^6\) EBIT is earnings before interest and taxes.
Figure 3

The value of the connected mobility market

Global market for automated and autonomous driving, including related services ($ billion)

<table>
<thead>
<tr>
<th>Year</th>
<th>Mobile apps with digital features</th>
<th>Apps and goods with digital and physical features</th>
<th>Special equipment (for high/full automation)</th>
<th>Fully autonomous vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>15</td>
<td>26</td>
<td>103</td>
<td>260</td>
</tr>
<tr>
<td>2025</td>
<td>13</td>
<td>28</td>
<td>95</td>
<td>260</td>
</tr>
<tr>
<td>2030</td>
<td>23</td>
<td>29</td>
<td>48</td>
<td>260</td>
</tr>
<tr>
<td>2035+</td>
<td>51</td>
<td>83</td>
<td>67</td>
<td>558</td>
</tr>
</tbody>
</table>

17% of total automotive market

7% of total automotive market

Source: IHS Automotive, Berylls Connectivity Compass 2014, Factiva, Just Auto, A.T. Kearney analysis

Figure 4

Self-driving will free up 1.9 trillion minutes of idle time in 2030

Global self-driving minutes* (billion)

<table>
<thead>
<tr>
<th>Year</th>
<th>Aggressive surplus scenario</th>
<th>Moderate scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>87</td>
<td>70</td>
</tr>
<tr>
<td>2026</td>
<td>266</td>
<td>53</td>
</tr>
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<td>2027</td>
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<td>34</td>
</tr>
<tr>
<td>2028</td>
<td>898</td>
<td>108</td>
</tr>
<tr>
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<td>180</td>
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<tr>
<td>2030</td>
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<td>267</td>
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<tr>
<td>2031</td>
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<td>492</td>
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<tr>
<td>2032</td>
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<td>618</td>
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<tr>
<td>2033</td>
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<td>748</td>
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<tr>
<td>2034</td>
<td>4,410</td>
<td>882</td>
</tr>
<tr>
<td>2035</td>
<td>5,102</td>
<td>1,020</td>
</tr>
</tbody>
</table>

CAGR = +50

*Long distance commuting only

Source: A.T. Kearney analysis
While the market will more than double between 2030 and 2035, the growth across categories will not be uniform. Revenue from special equipment for autonomous driving will peak around 2030, after which technology will start to become a commodity. Revenues from content, software, and services will exceed revenues from special equipment. Meanwhile, revenues from the self-driving vehicles will almost triple. So-called derivatives will also play a role in the market as autonomous driving vehicles are designed for even more narrow purposes and are well-suited to perform only these given tasks.

The apparent quantum leap in both technology and revenue from 2015 to 2035 will not be a single leap but a steady and rapid progression through a series of generations (see figure 5). The transition to fully autonomous will also be gradual and steady. It will follow a technology roadmap that includes mobile broadband systems, vehicle radar and location systems, and automation or robotic drive technologies using big data infrastructure management such as augmented reality. Tapping into this vast potential will require unprecedented levels of collaboration and cooperation among OEMs, telecommunications firms, media and Internet companies, and government bodies.

By far the most compelling part of this story is not the forces that give rise to mainstream autonomous driving. Rather it is the high-stake question of which company, or alliances of companies, will harness these forces to win the largest and most lucrative share of the market. It is dangerous to assume that the sheer size of the market will guarantee that everyone is a winner and that the only difference in success is a matter of degree.
The products

The always-on consumer requires connectivity. Connected mobility changes the automotive market in two fundamental ways. First, it creates new service opportunities. The more interwoven the concepts of connected and mobility become the more sophisticated the market solutions will be—all the way up to connected urban centers with advanced management systems to optimize the flow of traffic. Second, connected mobility creates new forms of competition as it opens up the market to connectivity specialists and blurs the lines between connectivity and mobility.

In this highly automated world, demographic, environmental, and technological forces will result in many new products and services that will spice up the mobility experience, not just make it more practical and efficient. We group these products and services into four categories: mobile apps, special equipment, autonomous vehicles, and infrastructure.

• Mobile apps. The mere existence of mobile apps can alter the role of the automobile. Apps enable consumers to treat their cars as extensions of their home, school, and office rather than simply a means to travel between them. Apps can also remotely manage the energy consumption and security at these locations, including turning on an alarm system, turning down the heating, or turning lights on or off. Drivers and passengers will use their smartphones or an app integrated into the vehicle.

These consumer-to-car (C2C) apps include entertainment, multimedia, and information. With autonomous driving, a solo “driver” can watch a live sports event, find a restaurant or a store, research a leisure destination, or relax and play a game, all without being a distracted driver. They can stay in touch with friends, family, and colleagues, and it is entirely feasible—and perhaps very efficient—to conduct a video conference from a moving vehicle while the vehicle drives itself. Speaking at Nvidia’s annual developer conference in March, Tesla CEO Elon Musk compared this process to taking an elevator: “They used to have elevator operators, and then we developed some simple circuitry to have elevators just automatically come to the floor you’re at. The car is going to be just like that.”

Apps will integrate the vehicle with a smart home, programming your home from the car or summoning the car from home. Apps will also provide more flexibility for insurance, safety, and legal protections. A consumer summoning a pay-as-you-go car can choose an appropriate package for that day, depending on the weather, the type and length of journey, and the number of passengers.

• Special equipment. Several OEMs have launched automatic parking assistance, and the feature is not limited to premium manufacturers such as BMW or Mercedes. Ford and Chevrolet also have models with hands-free parking. This is only the warm-up act for many practical features to follow in the form of driver-to-car (D2C) communication.

The next step is automatic driving or “chauffeur mode,” which will offer more comfort for the driver. This technology already exists in a practical form, as Audi proved in the run-up to the 2015 Consumer Electronics Show in Las Vegas. A team of engineers and journalists traveled about 550 miles (900 kilometers) from Silicon Valley to Las Vegas in a specially equipped Audi A7. The drivers engaged the autopilot with a press of two buttons in the steering wheel. The car then sped up, slowed down, and switched lanes—all without human intervention.

7 Elon Musk: self-driving cars could lead to ban on human drivers. The Guardian, 18 March 2015
8 Audi Drove This Auto-Pilot Luxury Car From San Francisco to Vegas. Business Insider, 6 January 2015
Now imagine that same trip on a conventional highway but with many more cars able to detect obstacles, respond to traffic conditions, and even communicate with each other. Car-to-car telematics (C2C) improve safety and mileage range, regardless of whether the car is gas-powered, hybrid, or battery-powered. It adds an important information element to decision making on the road that humans lack. Even drivers with the greatest skills, experience, and judgment never know with certainty what the other cars on the road will do. By communicating with each other to resolve problems on the road, cars travel in a coordinated way and reduce the need for stop-and-go, frequent acceleration and deceleration, and other abrupt ways that we cope with traffic.

- **Autonomous cars.** Fully automated driving means drivers and passengers can lean back for the entire journey as the car finds the best way to get to the destination, including any required parking or other stops. Self-driving cars can form platoons, or groups of interconnected cars with a fixed distance and speed. They can also swarm, which means the car gives control to a real-time automated traffic flow management system. That system takes the demands of a group and its individuals into account to make the best use of available roadway, whether it is passenger cars or commercial vehicles. We expect partnerships to spearhead development of several types of autonomous cars, each designed for a narrow purpose. These include premium high-end lounge vehicles and travel and experience vehicles, simpler vehicles and taxis for commuting and short family trips, and drones that can increase information density and capacity and offer options for speed.

- **Infrastructure.** The powerful communication that enables these previous categories will require a different infrastructure from that found in today’s highways and cities. Fortunately, most of this new infrastructure can overlay or work with existing roadbeds and communication systems rather than replace them. The first step is to ensure that networks, protocols, and standards exist for real-time interconnection between cars and other entities. The second step is to install platforms for automated traffic control on highways and in urban areas to enable robotic driving.

**Competitive Landscape:**
**You Won’t Recognize It 20 Years from Now**

To say autonomous driving will reshuffle the auto industry is putting it mildly. When connected mobility is the umbrella phrase to describe vehicular transportation over the coming decades, new players—especially from the “connected” side—will want to interact directly with consumers. OEMs need to selectively claim new touch points with their current and potential consumers as protection from these threats.

As you might imagine, traditional automotive OEMs are not about to concede the public’s mind and money to companies such as Google and Tesla. OEMs have no plans to become the short-sighted “buggy whip manufacturers” of the 21st century and have begun to fight back with their own groundbreaking initiatives. They have altered their branding in anticipation of autonomous driving and intensified their research and development efforts. Most OEMs have set a timetable for commercial availability of semi-autonomous driving within the next two to four years.

These initiatives are important as the automotive industry takes the first step along the technology roadmap that leads to fully autonomous driving. But these initiatives do not necessarily account
for two inevitable changes in the automotive industry: the value chain, which describes how players work together to produce a vehicle and take it to market, and the value share, which describes the sources of the vehicle’s total value and their relative contributions. The following takes a deeper look at both:

**Value chain: from value “pyramid” to “hub and spoke.”** The existing value chain in the automotive industry is best described as a pyramid, with the OEMs at the apex. Under them are several tiers of suppliers, ranging from raw materials and component suppliers at the base (third tier) up to systems suppliers and fully integrated production partners (tier 1 and 0.5 tier).

The new logic is neither a chain nor a pyramid, but rather more of a hub-and-spoke arrangement. The finished vehicle remains at the center, surrounded by indispensable and in some cases interconnected parts of a wheel: tier-x suppliers, the OEM, IT suppliers, online players, telecom companies, and device manufacturers (see figure 6). Remove any part, and the wheel doesn’t roll. The player that controls the customer relationship makes the wheel spin. For decades, the OEM held that responsibility. That might not be the case 15 years from now.

**Value share: vehicle value undergoes a tectonic shift.** As the logic underpinning the automotive industry changes from a pyramid to a wheel—or perhaps even because of this...
change—the value of a car will also undergo a tectonic shift. This will add to the pressure on OEMs. Today, the value for an average automobile is 90 percent hardware and 10 percent software. The future value looks much different. Hardware’s share plummets to 40 percent and its profit pool shrinks. Most of the value lies in software (40 percent) and content (20 percent), including the apps that bridge and integrate the hardware and software.

We expect software and content providers to achieve the highest margins. The most likely candidates to lead this area are technology companies with know-how in apps and operating systems. Automotive software providers will have less profitability than content providers but will still have better margins than hardware providers. These software companies could be technology firms, existing OEMs, or automotive suppliers that recognize the opportunity and make an early move to capitalize on it. While all relevant technologies exist for autonomous driving, the ability to integrate car software architecture and speed up software development must make major leaps forward (see figure 7).

Incumbent OEMs and their suppliers will still dominate automotive hardware because of their process expertise, but commoditization and a much lower value share will put their profits at considerable risk. Another crucial point is the growing gap between the life cycles of software and content platforms, their modules, and vehicle hardware. An individual module may have a very short life cycle, but modular programming or agile software development could allow a software platform to have a life cycle of up to four years—twice as long as the life cycle for hardware, such as semiconductors.

Figure 7
Software for connected cars needs improvement

Note: ECU is engine control unit.
Sources: Autoliv, Morgan Stanley
Five categories of competitors

We group the competitors in the market for connected mobility and ultimately for autonomous driving into five categories: luxury OEMs, middle-class OEMs, low-cost OEMs, tier 1 suppliers, and wild cards (the disruptive newcomers to the automotive world). Who will survive as this shift in value occurs? From within the existing automotive industry, we believe the luxury OEMs and some tier 1 suppliers will emerge as winners, provided they start to specialize in software. The wild cards may be the biggest winners of all, or at least produce constructive failures that leave a compelling legacy. In contrast, the middle-class incumbent OEMs are in a precarious position.

In this section, we discuss the prospects and challenges for each of the five categories, along with our recommended courses of action.

**Luxury OEMs: Invest in software, seek alliances**

Examples: Audi, Porsche, Mercedes-Benz, Lexus, and BMW

Luxury OEMs face several challenges. They must uphold their technology reputations while also realizing that no matter how advanced their own technology is, they cannot succeed without support. In the old pyramid structure, this meant finding and vetting the best suppliers. In the new hub-and-spoke world, it means finding the right allies and establishing partner networks and ecosystems. Recent strategic moves indicate companies have begun strengthening their positions (see figure 8).

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**Figure 8**

**Ecosystem partners are strengthening their positions in the value chain**

<table>
<thead>
<tr>
<th>Strategic moves</th>
<th>Content providers and aggregators</th>
<th>Application and service providers</th>
<th>Access network</th>
<th>Devices</th>
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<td>Verizon at&amp;t</td>
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<td>BMW</td>
<td></td>
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<tr>
<td>to expand via partnerships or integration</td>
<td>U-verse</td>
<td>Sirius Satellite Radio</td>
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<td>along the value chain</td>
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<tr>
<td>HMV</td>
<td>QUADRANT</td>
<td>Bell DirecTV at&amp;t</td>
<td>TiVo</td>
<td>HMV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WebTech</td>
<td></td>
<td></td>
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</tbody>
</table>

Source: A.T. Kearney analysis
Also, luxury OEMs must assess their core capabilities and establish a make-or-buy strategy to fill any gaps. Daimler, for example, wants to cooperate with Apple on off- and onboard systems and on applications for easy-to-handle monitors, while BMW wants to collaborate with Apple on connectivity and human-robotic interface (HMI) applications (see figure 9).

![Figure 9](image-url)

**Companies will join forces to create powerful ecosystems**

Of the two, BMW will likely struggle to build strategic alliances on this activity field. If BMW overcomes some challenges, it could capture first-mover advantage in this competitive race. The automaker can also create “walled gardens,” proprietary information worlds where its customers can interact and neutralize the advantage of Silicon Valley firms in this area, or prevent potentially unfavorable partnerships with them.

Let’s explore the walled garden concept. Imagine OEMs starting their own kinds of “Google world” where free-spirited millennials find their preferred automotive brand and then subscribe to a comprehensive mobility plan that lets them experience the whole planet in whatever mode they choose: on their own, with a robotic driver, or together—all traveling in group mobility mode. In addition, a premium OEM might offer its own app, an onboard hardware feature package, or distinctive spinoffs with equipment for autonomous driving (such as a lounge, adventure, or peer-group transportation concept).

On the other side, non-automotive players continue to change the game—cooperating with automotive OEMs to achieve the market’s pole position.
**Middle-class OEMs: Deep trouble ahead**

**Examples: Toyota, Volkswagen, SEAT, and Citroën**

Any market has a thriving middle when competitors offer “best of both worlds” combinations that appeal to a large base of consumers. Such companies build their brand on complementary phrases such as “affordable luxury.” On the flipside, the middle of the market can be an area that is neither fish nor fowl and thus has far fewer consumers.

Middle-class OEMs fall into the latter position. Wedged between luxury OEMs and low-cost OEMs, they will struggle to find a value proposition or key selling point in the era of autonomous driving. Their target price range is too low to please early adopters, but too high to sustain them when technology becomes a commodity.

These mid-range companies are also focusing on business-to-business premium offerings, bundling equipment for connectivity and human-robot interaction. They also want to develop modules to offer commuters various powertrain options such as e-vehicles and hybrids.

Middle-class OEMs will try to focus on connected services and telematics, filling apps and equipment hardware packages much like the early adapters (GM, BMW, and Ford) considered car telematics a core element of their development strategies (see figure 10). To expedite time to market, mid-class OEMs will want to form strategic alliances with strong non-automotive partners. And to secure a viable role between the premium and low-cost segments, they will create a solid and balanced mix of off-board and onboard intelligence, radio frequency input, and auto-robotic driving.

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**Figure 10**

**Early adapters will build car telematics into their strategies**  

**Non-exhaustive**

**The evolution of connected services**

<table>
<thead>
<tr>
<th>Year</th>
<th>Service/Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>OnStar by GM</td>
</tr>
<tr>
<td>1998</td>
<td>VOLVO On Call</td>
</tr>
<tr>
<td>2000</td>
<td>BMW Assist</td>
</tr>
<tr>
<td>2002</td>
<td>PSA Peugeot Citroën</td>
</tr>
<tr>
<td>2004</td>
<td>BMW Pan EU telematics</td>
</tr>
<tr>
<td>2006</td>
<td>Mercedes-Benz Teledt</td>
</tr>
<tr>
<td>2007</td>
<td>PEUGEOT</td>
</tr>
<tr>
<td>2008</td>
<td>OnStar and Toyota Entune</td>
</tr>
<tr>
<td>2010</td>
<td>OnStar and Toyota Entune (China)</td>
</tr>
<tr>
<td>2011</td>
<td>Mini Connected GM my link</td>
</tr>
<tr>
<td>2012</td>
<td>Hyundai BlueLink Toyota Entune OnStar FMV</td>
</tr>
<tr>
<td>2013</td>
<td>eCall mandate</td>
</tr>
<tr>
<td>2015</td>
<td>Increase in telematics subscribers</td>
</tr>
</tbody>
</table>

**Sources:** Frost & Sullivan, A.T. Kearney analysis
Low-cost OEMs: Invest in software and seek alliances
Examples: Dacia, Kia, Hyundai, and Daewoo

The hub-and-spoke value chain puts a premium on partnerships. No category is in greater need of such technology partnerships than the low-cost OEMs, which need to compensate for their limited R&D resources. Their experience with a low-cost production process, and the ingrained culture that supports it, should enable them to develop low-cost, self-driving cars. If they can establish positions as the suppliers of automotive drones, they can carve out a niche and be ready when technology becomes a commodity and infrastructure matures.

Google or Apple might collaborate with low-cost OEMs to offer extraordinary communication and auto-robotics platforms using tactile Internet and mobile broadcasting systems. For example, Hyundai BlueLink provides an onboard system plus smartphone plus Web platform that offers navigation, emergency alerts, protection, communication, maintenance, remote access, and three packages to choose from with increasing levels of service. If the goal is to find the best way to pair “connected” with “mobility” to create an appealing and affordable package for consumers, the leaders might be best served to work with efficient manufacturers of low-cost transportation instead of making connected mobility a premium offering in all aspects.

Tier 1 suppliers: take over hardware, or specialize in software?
Examples: Bosch, ZF/TRW, Continental, and Schaeffler

Tier 1 suppliers face perhaps the greatest range of options and challenges among existing automotive industry players. The first challenge is to maintain a competitive position as high-quality suppliers. Then they must decide between two strategic directions, both of which are a fundamental departure from their current strategies. They could move upward in the thinking of the old pyramid structure and displace OEMs as hardware suppliers. Or they could shift the focus of their value creation from hardware to software and the components that support it.

We recommend the second option. Tier 1 suppliers should prepare for a shift in value creation from hardware to software. In the short term, this means making R&D investments in sensors, devices, and other critical components; in the long term, they need to establish reputations as software suppliers, not just hardware suppliers.

Wild cards: win or lose, they will be very influential
Examples: Google, Apple, Facebook, Cisco, Uber, and Microsoft

The self-driving car as a consumer product and platform for services opens up the market not only to current manufacturers, but also to wild card firms. Each wild card brings its own global strengths to help make autonomous driving part of new mainstream lifestyles. These companies built their reputations and fortunes on “connected” and relish the opportunity to pair “connected” with “mobility.”

They have also witnessed, profited immensely from, and in some cases instigated previous transformations of physical business models into digital ones. Think of music and movies, established industries where millennials prove an industry can be transformed in the span of a generation. Movies and music are not something millennials own but rather something they summon at will to fit their needs, whims, and circumstances. It will be no surprise if they prefer to summon a car on demand or on subscription, as they do with their music and other entertainment forms, rather than own it. In this spirit, we predict revenues from pay-per-use services will exceed revenues from optional onboard equipment from 2025 onward.
Another threat to incumbent OEMs is the potential price advantage a company such as Google might claim. Driverless cars from Google are not only passenger transportation, but an ingenious data collection system. If passengers feel comfortable exchanging rich data—telemetry, pictures, and videos—in exchange for a ride, Google can significantly lower the barriers to access. There is no reason, however, why the incumbent OEMs cannot either pursue a similar strategy or neutralize Google’s. This will be a question of their ability to develop core competencies in data and information or find the right attractive partners to create an experience for consumers.

Despite all these positive headline-grabbing prospects, the wild cards face challenges. They need to find a way to expand their existing platforms and networks into consumers’ cars and then anchor them there. Then they need to take advantage of transaction data to earn money from their value-added offerings.

Most original equipment manufacturers have set a timetable for commercial availability of semi-autonomous driving within the next two to four years.

Another potential outcome is that consumer demand and technological edge will force OEMs to integrate rival platforms such as Android and Apple’s CarPlay into their cars, essentially waving the Trojan horse through the gates with full knowledge of what is lurking inside. These players will not earn their money with the car value itself (the hardware or the engine). They enter the market with new forms of connectivity, human-robot interactions, auto-robotic drive, and new telematics. Their attractiveness will derive from the mix of information, media, mobility, and speed, perhaps coupled with an e-drive concept.

The car will also not be sold over an upfront purchase price. We envision that a Google or Apple car will be financed by pay per use, fees, flat subscription prices, or licensing. Money will also be made from short churn cycles on lifestyle apps as well as mobility services and mobile speed applications, which receive annual, monthly, or even daily updates. These companies calculate on a profit margin of 10 to 15 percent, but the more highly appreciated features could help them achieve outstanding, breakthrough margins of around 20 to 22 percent.

Let’s take a look at some of the recent steps of the more prominent wild cards:

**Google**
- Unveiled a second-generation prototype of its self-driving car project, Google Chauffeur
- Acquired a military robotics maker
- Developed Google Nest for smart-home integration
- Created Android Auto to expand into the car, starting with tactile Internet applications
Apple
- CarPlay opens the door for Apple’s iOS operating system to be integrated into the car
- The HomeKit interface enables integration with smart home devices
- iCloud hosts a comprehensive database of customer data; expect Apple cars to feature high-density information and mobility velocity that does not come at the expense of speed

Rinspeed
- Developed the XchangE concept car in cooperation with A.T. Kearney to showcase the potential of fully autonomous cars (see figure 11)
- Focused on self-awareness to enable advanced features such as cross-car communication and adaption to a driver’s habits and preferences

MirrorLink
- Formed a cross-industry alliance of hardware and software for handheld devices (LG, Nokia, Panasonic, Samsung, Sony) and in-car equipment (Alpine, JVC, Pioneer)
- Developed an open interface for connecting users’ smartphones and certified car interiors

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**Figure 11**

**Rinspeed’s concept vehicle: a glimpse into the future**

**Examples**

<table>
<thead>
<tr>
<th>Individual connectivity</th>
<th>Group connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility with docking and charging hubs</td>
<td>People-to-people and car-to-car communication</td>
</tr>
<tr>
<td>Induction</td>
<td>Car-to-third party connectivity</td>
</tr>
<tr>
<td>Conduction</td>
<td>- Parking lodge</td>
</tr>
<tr>
<td>Real-time availability check, reservation, and payment</td>
<td>- Car parts: go and load</td>
</tr>
<tr>
<td>Board system</td>
<td>- Energy net for loading station</td>
</tr>
<tr>
<td>FleetBoard</td>
<td>- Rush hour</td>
</tr>
<tr>
<td>myBoard</td>
<td>- Traffic accidents</td>
</tr>
</tbody>
</table>

**Infrastructure technology**

Source: A.T. Kearney analysis
Technology: from Driver-Centric to Connected Mobility

As autonomous driving technology evolves and adoption becomes more widespread, we envision three lanes of highway traffic—a premium lane, commuter lane, and drone lane. Each lane corresponds to the product segments with best success prospects, and each is defined by the nature and sophistication of their embedded technologies.

Imagine standing on an overpass that spans a three-lane expressway. Looking down, you see cars whizzing by in the left-hand lane. These are the premium vehicles, driving themselves with no speed limit. What nameplates will these premium cars carry? This is where we have the greatest certainty over what brands you will see: Audi, Porsche, Mercedes-Benz, and BMW—the same brands that fill the high-speed lanes on expressways and autobahns today.

The nameplates in the other lanes are far less certain. In the middle lane are the commuter vehicles, traveling within predefined speed limits. Designed for short, regular trips that allow passengers to seamlessly continue their always-on lives, these vehicles create many opportunities to trade-off features against price to optimize the vehicles and keep them affordable.

The right lane is the domain of the drones, with speed that varies according to the demands and destinations at any given moment. The mix here can include all kinds of service vehicles, from taxis and delivery to specially designed vehicles for shopping, doctors’ visits, and school transportation.

Regardless of the nature of these vehicles, they all fall under two large umbrellas: car-centric communications and an overarching legal framework. These umbrellas provide the forms, leeway, and definitions that lay the groundwork for the autonomous driving boom.

The technology umbrella: car-centric communications

The basic technologies to enable autonomous driving either exist today or are being developed and refined. These are the puzzle pieces that bring autonomous driving to life. But puzzle pieces are useless unless assembled. This is the challenge that OEMs, wild cards, and their technology partners face in realizing the full potential of this multitrillion-dollar opportunity.

The future of autonomous driving will have less to do with the mechanics of the vehicle and almost exclusively to do with forms of interconnection and car-centric communication. This is the future hardware side of connected mobility. It underscores why alliances and partnerships are the ideal ways to make autonomous driving desirable and practical. No company has a base of competencies broad enough to establish a global, 360-degree system for navigation, control, and automation, built on a stable stationary and mobile broadband network. And no company will succeed on its own. Groundbreaking partnerships and alliances are mandatory.

The easiest way to appreciate and understand the communication complexity is to look at the various combinations necessary to make autonomous driving a desirable, practical reality. As shown in figure 12 on page 22, there are four main communication connection points: consumer to car (C2C), driver to car (D2C), car to third parties (C2X), and third party to third party (X2X).

1. Consumer to car (C2C)

The first human-car interaction comes when we decide to take a trip of any kind. Today, the four most common next steps are to get into one’s own vehicle, hail a taxi, use a ride-share service, or rent a vehicle. In the future, the exchange of data between the consumer and car occurs long before any of these steps thanks to technology.
Customers will have access to their personal data either via cloud services or physical and personal storage devices via OEM-promoted Internet access suites. Storing, providing, managing, and analyzing that data helps cement the relationship between the customer and the owner of the gateway. This helps explain why ride service giant Uber wants to convert its fleet to self-driving cars. In February, Uber confirmed it has entered a strategic partnership with the Carnegie Mellon University Robotics Institute to develop self-driving cars.

When a rider orders a rental car and the car arrives, the car needs to know it has reached the right person. The rider will also need to synchronize his personal data with the car, whether it is his own vehicle or a rental. This includes everything from how the rider obtains the vehicle, interacts with the vehicle in terms of data exchange (payments, destinations, and other information), and returns the vehicle when the trip is completed.

Today, Daimler has 10 applications that can be preinstalled on a black box or via the Internet. Figure 13 on page 23 illustrates its FleetBoard cockpit showing both the operator and driver view. These cover aspects such as car check control, preventive maintenance, energy usage, and automatic control of select services to avoid the frustrating, unexpected downtime of a vehicle breakdown. Customers become sensitive to the same issues that manufacturers know intimately, namely that unplanned downtime is their costliest hazard.
The solutions include hardware-software connectivity with the vehicle’s main control board. These assume standards for tactile and stationary Internet and proper interfaces such as internal and external docking stations for smart devices. We can imagine that one day keyless access and keyless operation will be the norm as the whole concept of physical driving and vehicle management is handled by a smartphone.

**Our hypothesis:** OEMs will propel development of smart devices, set future smart technology standards, and offer in-house hardware and software modules.

OEMs will figure out how to integrate and apply Internet access and power as well as how to organize and manage data storage. The ability to accumulate historical information—about vehicle performance, its tendencies under certain conditions, demand fluctuations on certain highways and city streets, and demand for additional services such as parking and ride-sharing—represents a tremendous advantage for the company that owns the data and can analyze it to achieve greater efficiencies, optimize services, or offer riders more reliable, data-driven, high-quality services. These include Daimler’s offer of the means to connect car telematics with traffic telematics.

**Our hypothesis:** Each OEM will collaborate with telecom companies or other partners to develop its own proprietary Internet brand and applications with a focus on all-encompassing consumer contact and support. Cars will be equipped with powerful onboard computers for mass data processing and storing.
The flipside of this power is privacy. Autonomous driving with cars on demand will be one of the most information-intensive activities consumers have ever undertaken. OEMs will have unrestricted access to the data generated in the context of autonomous driving—starting with personal basics such as address, bank account, and billing information as well as the telemetry data from a trip, including route and destination. Cars collect data much the same way the black box on an airplane tracks and records hundreds of parameters. The amounts of data transmitted in real time will be massive. Potential cyberattacks will lead to additional measures from the OEMs to safeguard their flow of data. Autonomous driving will be an irresistible target for hackers.

2. Driver to car (D2C)

Human-car interaction also begs the question of control. What will be the center of intelligence when autonomous driving becomes commonplace? For more than a century, the sole source of intelligence on the highway has been the driver. Think of all the stressful decisions a driver has to make on a trip into a congested city: Is it better to take the highway and pay a toll, or take a back road? Do you switch routes if you hit unexpected traffic? Is it better to park at the big garage or the small lot?

The ultimate question is how to handle the human-car interaction most efficiently and what information from the outside world is crucial. OEMs will need their own radar and interface capabilities provided by satellite and drone service providers and also computing centers, as discussed on page 25 in the section on C2X communication. We expect control of the car to be denied to a driver in statistically error-prone situations, as discussed in the legal umbrella section on page 28.

Every car will carry one central data system with interfaces for OEMs, car sensors, other cars, the driver, local hubs, satellites, and mobile networks. Figure 14 provides an example of a D2C situation in which the consumer starts an autonomous driving journey with a rental car that is under 360° multidirectional control and surveillance. Some of the state-of-the-art sensors—including autonomous parking, fuel-efficient driving, and crash avoidance—are already available from a range of OEMs and not just in the premium segment.

Figure 14

A consumer’s autonomous driving journey with a rental car

Example

Driver-to-car system
How Automakers Can Survive the Self-Driving Era

Sensors and transmission technology come into play whenever cars encounter objects, such as other cars, bicyclists, pedestrians, and natural or man-made barriers. They are essential for crash avoidance and autonomous parking, and they must perform to extremely high standards. Rational or not, society will hold cars driven by computers to a much stricter safety standard than cars driven by humans. In fact, the goal for autonomous driving is zero failure.

The question now is which OEMs and company alliances will drive these developments forward. It will be a massive undertaking. Manufacturers need to improve the performance and placement of sensors to ensure that cars receive and transmit precise information. They need to address basic questions of communication between cars. When cars drive themselves, it is the car itself that needs sufficient real-time communication to understand what other drivers are doing. The greater the ability of the car to sense its surroundings, recognize other cars in front or in back, process that information, and exchange signals with neighboring vehicles, the more reliably it can make decisions such as switching lanes, slowing down, or taking an alternative route. Cars will have far more information for decision making than humans ever could.

Also, the practical and technological aspects of the handoff between human and machine must be defined. The most common instance will probably be in some emergency situations when humans need to work with the vehicle or assume control themselves. One dimension here is the direct transmission of information. Drivers will need to connect with the car either directly via a mechanical interface or indirectly by using their smart devices for seamless lifestyle integration. However, drivers will always have an option to take manual control of the vehicle if a critical chain of events occurs in certain traffic situations.

Our hypothesis: OEMs will enter partnerships with telecommunications and hardware and software suppliers to co-develop next generation technologies. They may also independently push for next-generation technologies, such as the development of high-performance nanochips to ensure a trouble-free autonomous driving experience. OEMs will also offer combined hardware and software solutions around smart device technology and data. Finally, OEMs in developed regions will rent capacity for computing, monitoring, maintenance, and surveillance. In other regions, they will build or facilitate building of the infrastructure.

As an example, imagine that BMW takes over the information flow in the Munich metropolitan area. We might see OEMs running the telematics centers in cities or urban areas and offering their own fleet of vehicles, as well as renting access to the whole infrastructure and data systems. This is another situation where a strategic partnership is essential, as the participation of a Cisco or an IBM in such a venture is extremely advantageous.

The sophisticated support systems built into today’s cars provide some intelligence and help with tedious decision making. But all of the stakeholders in autonomous driving, especially consumers, face a fundamental question: what will the smartest part of the future system be? Will the car of the future be smarter than its passengers? Or even more futuristic and ominous: will the entire traffic management system be smarter than both?

3. Car to third parties (C2X)

Communication and physical infrastructure are necessary for cities and their residents to make the most of autonomous driving. From the standpoint of commuters and residents of megacities, the challenge is to get cities connected to cars and to centralize information gathering and traffic management. For vacationers, business travelers, and logistics companies, the challenge is compatibility, or what is called “roaming” for mobile telecommunications. Cities such as
Berlin, Shanghai, Singapore, and Austin are changing to more intermodal mobility-based infrastructures in which they are becoming smart cities with the following characteristics:

- Sustainability measures and dashboard
- Management of tenants and city services
- Control of multiple providers and city operations
- Advanced monitoring systems for sustainability
- Complex transport and logistics systems
- Free zone administration

The idea is for cities to develop their own micro-mobility centers so vehicles can move seamlessly from city to city while staying connected (see figure 15). These could be vehicles with consumers who made their own ad hoc decisions to travel, or they could be autonomously driven electric vehicles for passengers or goods moving between cities on predefined routes. Someone needs to ensure compatibility, which means not only the integrity of the communications to support the vehicle on the road, but also the personal and financial side. Cities and regions will want to collect taxes or tolls, and service providers—telecom, insurance, entertainment, Internet media, software—will want to track usage and charge for their services, all in real time via subscriptions, flat rates, or a payment bonus accrued through usage, miles, and other loyalty programs that can prove to be a powerful incentive for consumers.

Cities can capture a significant competitive advantage from these services, including attracting anyone who wants to enjoy the virtues of city life. OEMs have a strong incentive to compete in this area as well. In fact, they have an opportunity to enter this area in much the same way

Figure 15

Micro-mobility centers keep vehicles connected from city to city

Source: A.T. Kearney analysis
outsiders such as Google, Apple, and Uber want to enter a capital-intensive industry (vehicle production) in which they have no experience. The company that provides a customer with a vehicle needs to ensure seamless, fast, and reliable communication along with compatibility and autonomous driving within and across two similar telematics landscapes. Toyota, one of the leaders in this challenge, is running a test model in Nagoya, Japan.

Our hypothesis: OEMs will invest in regional telematics infrastructures or pay a fee to ensure full compatibility of systems. They will compete for leadership by developing proprietary mobile broadband frequency with global coverage—either in partnerships or on their own—and will build collaborative partnerships to run autonomous driving across cities and regions.

Another big wave of the future is the tactile Internet and mobile broadband, two technologies that can accelerate the transition to self-driving cars. Instead of asking governments and taxpayers to retrofit thousands of miles of existing highway with cables and sensors, OEMs can pack the necessary sensing, guidance, control, and communication equipment into the cars. The emergence of D2C and C2X communication—facilitated by the tactile or mobile Internet—means the roads can remain “dumb” while the vehicles collect and exchange information to guide their passengers through traffic.

Connected mobility within and between cities is important. Consider how navigation, control, and automation work on a global scale with all the competing players, systems, and infrastructures. Connected cars will travel in three categories: premium lane (high intelligence), commuter lane (shared intelligence), and drone lane (external intelligence). Everyone will want a piece of this lucrative business and will think their contribution is the one that will govern the customer relationship.

4. Third party to third party (X2X)
We conclude this section with X2X, or communications between third parties that are relevant for cars on the road. Let’s say a customer—perhaps an individual or a logistics company—wants to make a trip from Portugal to Russia via autonomous driving. Such a trip would include changes in language, speed limits, traffic laws, and driving habits, along with changes in measurement systems if the trip is from the United Kingdom (miles) to France (kilometers).

Autonomous driving between different telematics and Internet landscapes adds a thick layer of complexity. This will require a new level of collaborative effort among countries and industry to create an infrastructure that enables 360-degree global steering, robotics, and automation, relying on external and internal intelligence. This infrastructure will need centralized and decentralized hotspots with local IT, data, and mobile broadcasting systems interconnected with stationary networks or hotspots. From the perspective of autonomous driving, country borders could be replaced by telematics landscape borders.

Various players in the autonomous driving market will figure out how to combine internal (car) and external (outside world) intelligence globally with different standards, IT systems, and digital infrastructures. Figure 16 on page 28 highlights some of the trends and partnerships that are making X2X communications a reality.

Our hypothesis: OEMs will develop proprietary mobile broadband frequencies with global coverage and that interface to their existing infrastructures. For a fee, cars will dock into the local traffic control and information system. OEMs will claim the premium segment for autonomous driving across regions, while the mass market remains up for grabs among many diverse players: software and hardware manufacturers, service providers, private equity firms, and even cities and regions.
The legal umbrella: an overarching framework

The legal challenge facing autonomous driving lies in changing and supplementing existing laws and regulations that never foresaw the advent of self-driving vehicles. No matter how strong the desire to speed up the transition, it will happen only as fast as several important and powerful pieces are put together over the next two decades, including technology, standards, infrastructure, legislation, and consumer readiness. Further, no one company can make this future a reality on its own.

While the first movers in this market will likely reap the greatest rewards, the market will require support from political systems to update laws and regulations, make transmission bandwidth available, and potentially approve infrastructure funding so driverless cars can take to the highways in large numbers. The following are the main legal issues to consider:
Licensing. Autonomous driving will extend the age as younger people, the elderly, and the disabled can ride as passengers. This is one of Google’s mobility approaches. Governments will need to create licensing and permit systems. Depending on the technological maturity and cultural acceptance, autonomous driving may demand more or less skill from the driver.

Implications: During the adoption phase, expect to see incremental adaptations in driving schools and new types of permits, and prerequisites for more skills from drivers until they grow accustomed to the experience.

Data ownership. Autonomous vehicles generate vast amounts of metadata. The question is who owns that data. With many parties having a stake in such data, conflicts of interest will be unavoidable, putting consumers’ privacy at risk. The list of potential stakeholders is long. OEMs, insurance companies, financial institutions, Internet firms, and law enforcement agencies, to name a few, will all try to gain access to the metadata generated by autonomous vehicles and the surrounding infrastructure. For example, OEMs can leverage their “data provision” position to help insurance companies increase their profitability. Costs are reduced as data on driving behavior is used to assess a consumer’s risk profile, and revenues can be generated via data on customer segmentation, value-added services, and customer loyalty (see figure 17).

Yet data ownership has a murky and perhaps sinister side, as well as applications that range from benign to beneficial. For example, smart device designers and manufacturers such as Apple, Samsung, and Google use code programming to push access to end users. But this restricts the major carriers—Vodafone, Deutsche Telekom, Sprint—from access to their existing license customers. Further, high-tech and broadcast technology companies that want to add more end consumers are reluctant to partner with the venture companies or other financial partners whose cooperation is necessary to buy an Internet media company. Time is running out even for the strongest industry giants.

The pooling of individual data for analysis purposes can make a smart system even smarter, as traffic control systems recognize tendencies, make evidence-based risk assessments, and optimize everything from time to energy usage in a collectively powerful way that individual drivers never could on their own.
Implications: OEMs will try to build “walled gardens” around their respective ecosystems and monetize them with proprietary interfaces.

Liability. If a crash involving one or more autonomous vehicles occurs, who is liable? Legal questions about responsibility (driver versus vehicle) will inevitably arise, involving executive as well as legislative powers. While the list of companies that want to participate in data ownership is diverse and long, no one wants to be on the liability list. But someone has to pay.

Implications: The first requirement is that governments set boundaries to the driver’s scope of responsibility. In the event of a crash between two autonomous cars and no obvious guilt on either side, we anticipate that insurance companies will have to split the damage. OEMs will make every effort to be free from any liability, even when a situation rules out human error.

Life or death. If an autonomous vehicle enters a situation where a crash is perceived as unavoidable, the vehicle might have to make a life-or-death decision in a split second. This raises an important ethical question: can a machine make such a decision? Even more extreme is a situation in which either a traffic control system needs to determine the least lethal crash scenario or the cars need to resolve it among themselves.

Implications: Algorithms will likely be developed for choosing the lesser evil—that is, choosing the option with the fewest or least severe casualties (see figure 18). OEMs will need to seek independent certification by third parties to ensure accurate functionality and avoid legal disputes, such as the Toyota anti-lock brake software recall in 2009-2011. It may also be possible for consumers to pay to reduce their crash probability. We expect some form of override so the driver can disrupt the ride in order to avoid or reduce the impact of a traffic accident.

Figure 18
Autonomous driving requires sophisticated communications

Technologies flow in parallel

Self-steering traffic junctions

1 Frequency technology such as LTE, GSM, and multi-user
Source: A.T. Kearney analysis
Answering the Tough Questions: OEMs’ Survival Depends on It

Incumbent OEMs will need to answer some vital questions with a combination of care, urgency, and decisiveness. Decisions must be made about how to harness the forces discussed in this paper, from the forces behind autonomous driving to the markets and products that will define the industry and to understand the competitive landscape, especially the threats and opportunities. Let’s go through the seven questions discussed at the beginning of this paper:

1. How can OEMs match consumer needs with autonomous driving solutions, while overcoming skepticism about relinquishing control of the vehicle?

In a world of autonomous driving where connected mobility is the core consumer benefit, OEMs will need well-crafted messages and the right value propositions in the areas that appeal to always-on consumers who want seamless access to information, communications, and entertainment. However, this seamless access is only one virtue. We expect other products to evolve to support driving that is autonomous, efficient, stress-free, and dynamic (see figure 19).

Autonomous driving creates environmental and cost benefits, including less toxic emissions and better fuel efficiency. In addition, there are tremendous savings in travel time thanks to features such as automated traffic flow management and automated parking. Safety and security improve as these vehicles reduce human errors from factors such as inattentiveness or falling asleep.

Figure 19
Products will evolve along four dimensions

Sources: Rinspeed, A.T. Kearney analysis
In the long run, reliable algorithms and mature technology will prove to be superior to human drivers. However, incumbent OEMs will need to help make that case by demonstrating that autonomous driving can transform the industry—and then take credit for it. No OEM should concede the headlines to the wild cards.

Consumer skepticism can be overcome by OEMs that encourage early adopters to experience autonomous driving. This will create a hype effect and show that the benefits do in fact outweigh the fears. In fact, OEMs can draw lessons from the early days of air transportation and how most people have now grown accustomed to the safety, reliability, and benefits of air travel.

In addition to the enormous societal benefits of autonomous driving, individual users will also improve their lives by giving up control of their vehicles. As discussed on page 4, autonomous driving will significantly improve safety and give consumers more time for other activities.

2. How will the market for autonomous driving develop, and what will the associated product roadmaps look like?

Until 2035, the market will grow up to $550 billion. In our scenarios, the largest segment is fully automated vehicles. However, retrofit and specialized equipment such as auto pilot and enhanced navigation for semi-automated driving will also be significant. The market for autonomous driving-related apps and other digital features will also grow but not as much as the vehicle market itself.

Autonomous driving is impossible without integrated communication. Much of the technology already exists or is imminently feasible. However, having the pieces to the puzzle does not mean the picture is clear. The company—or the alliance—that puts together the most compelling picture will have the advantage. In particular, we are talking about the three types of communication technologies for transmitting massive amounts of data in real time:

- **Short range**: sensors with indisputable reliability (ultrasonic, infrared, radar, and real-time image processing)
- **Medium range**: cellular networks with gapless coverage, bandwidth, and latency (UMTS/3G, LTE/4G, and eventually 5G and 6G)
- **Long range**: satellites with guaranteed availability and coverage (GPS/GLONASS)

The emergence of services and the connected, always-on consumer are already initiating new business models, and this will escalate in the years ahead (see figure 20 on page 33). Large new revenue sources will come from two sources:

- Giving customers in autonomous vehicles value-adding services such as city guides, local deals, automated parking, and traffic jams in exchange for their personal data
- Monetizing customer data using a network of third-party content and service providers; by 2025, we expect pay-per-use service revenues to outperform optional equipment revenues

3. How will government legislation keep pace with new technologies while also addressing questions of liability?

The market will require support from political systems to update laws and regulations, make transmission bandwidth available, and potentially approve infrastructure funding so driverless cars can take to the highways in large numbers. If a crash involving one or more
autonomous vehicles occurs, who is liable? Legal questions about responsibility (driver versus vehicle) will inevitably arise, involving executive as well as legislative powers. While the list of companies that want to participate in data ownership is diverse and long, no one wants to be on the liability list. But someone has to pay.

The first requirement is that governments set boundaries to the driver’s scope of responsibility. In the event of a crash between two autonomous cars and no obvious guilt on either side, we anticipate that insurance companies will have to split the damage. OEMs will make every effort to be free from any liability, even when a situation rules out human error.

Autonomous vehicles generate vast amounts of metadata. The question is who owns that data. With many parties having a stake in such data, conflicts of interest will be unavoidable, putting customers’ privacy at risk. The list of potential stakeholders is long. OEMs, insurance companies, financial institutions, Internet firms, and law enforcement agencies, to name a few, will all try to gain access to the metadata generated by autonomous vehicles and the surrounding infrastructure.
4. What business models will win in the new industry?

In the “competitive landscape” section, we examined each segment in the industry under its traditional business model and predicted the challenges and futures that lie ahead. We concluded that the premium segment will maintain its technological lead by cooperating with hardware manufacturers. Companies in the low-cost segment can succeed by developing inexpensive autonomous drones or making their efficient production platforms available to the wild cards. Companies in the middle-class segment face the greatest danger, for as their products lose their emotional appeal a collapse in demand is a very real possibility.

In addition to the always on consumer, incumbent OEMs will need to consider other aspects when determining their future business models:

- **Consumer control.** In mobile communications, consumer access is owned by device manufacturers with strong brands and access network providers trying to keep their stakes. This is in sharp contrast to today’s business model in which OEMs control the customer relationship.

- **Branding.** Most important for device and content providers is the ability to differentiate an otherwise commoditized offering. As application and service providers create strong brands through “killer apps,” how can the incumbent automotive OEMs compete?

- **Data ownership.** Customer transaction data is traditionally controlled by access network operators; application and service providers can capture some data on user profiles, but its value is to advertisers. How much data will OEMs be able to capture, control, analyze, and use to their advantage?

- **Privacy and security.** Personal data theft and privacy invasion through location data are significant concerns. Yet the divulgence of personal data could become a primary means for companies such as Google to lower the price to use or “own” their vehicles. That same willingness to reveal data underpins many Internet and telecom business models. Can the incumbent OEMs play this same game?

- **Intellectual property.** IP helps define industry standards and protocols that establish a base for interoperable systems and devices. Intellectual property issues become even more important as players try to gain control of the value chain. For example, insurers with usage-based insurance (UBI) programs say that access to more data will allow them to segment and pool drivers more effectively than using traditional risk-pricing models in which customers are categorized into a few segments based on static parameters such as sex, age, and location. With UBI customers are categorized into detailed segments based on new parameters, including speed, number of hours driving, miles, and location (see figure 21 on page 35). Armed with more detailed data, insurers are able to open up new areas of business and propose custom tariffs to customers.

5. What role will partner and competitor ecosystems play in autonomous driving?

Partnerships are essential to success in autonomous driving. No company has the capabilities on its own to cover all of the key elements of a connected mobility experience. Given the diverse capability requirements across the value chain (R&D for application providers, capex for access providers), partnerships are vital to providing an end-to-end connected solution.

The first OEM to build a compelling partner network will secure the pole position and have the best chance to lead and win the race. The traditional value creation pyramid will change into
Figure 21

Opportunities are opening up for players outside of the automotive industry

Usage-based insurance

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<tr>
<th>Traditional risk-pricing model</th>
<th>Potential new pricing model</th>
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<tbody>
<tr>
<td>• Age</td>
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Categorizing customers in a few segments based on static parameters such as sex, age, and location due to the limited availability of data

Categorizing customers in detailed segments based on new parameters such as speed and sprinting

Source: A.T. Kearney analysis

a hub-and-spoke network structure, which creates opportunities not only for OEMs but also for their suppliers and large, established companies from outside the industry.

To maintain their customer relationships, OEMs must change how they interact with customers, moving from transactional interactions to a process of permanent digital interactions. Because the customer is “always on” an OEM must likewise be always connected with the customer. Connectedness is one reason why OEMs need to expand their scope beyond cars to other areas, including infrastructure.

Who’s Who in a Race to the Future?

No one knows for sure which players will dominate in the race for autonomous driving and which ones will falter. But we do know that the formation of strategic alliances and the choice of core competencies are the most urgent decisions incumbent OEMs face. The companies seeking a stake in this market—whether inside or outside the industry—are well-known global leaders with large customer bases and in many cases very large war chests. The more alliances that begin to form, the greater the risk that some companies will be left behind.

Several plausible scenarios reflect both the stakes involved and the kinds of partnerships that will form to make autonomous driving a self-fulfilling prophesy. Imagine the following partnership scenarios:

**OEM and telecom.** Daimler partners with Nokia to gain access to connected end customers. Daimler offers its proprietary world of data and information via a smartwatch under its own brand name.

**OEM, telecom, and Internet.** BMW and Vodafone cooperate to make the first BMW Microcity Munich a reality. The exclusive and proprietary network includes a BMW tablet, manufactured in cooperation with Amazon.
Infrastructure and Internet. Cisco wins the public bid to build the 5G and 6G network in California by 2017 or 2018. It begins a close cooperation with Google to create Google’s own network and infrastructure frequencies.

Internet and wild card OEM. Google buys or partners with Tesla and gains access not only to electric vehicles but also to operating models for battery-powered homes.

OEM and infrastructure. GM cooperates with IBM or General Electric to provide complete infrastructure and connected mobility solutions for U.S. megacities.

OEM and services. Chinese auto manufacturer Chery launches a car-sharing service in Shanghai and Hong Kong.

These scenarios are intended to fuel a discussion about who can partner with whom and how that creates more value for consumers than other forms of partnerships. Forward-thinking OEMs will act now. The clock is ticking.

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Postscript: Implications of Fatal Collision of Tesla Model S

In early May 2016, a 40-year-old man was killed in northern Florida when the Tesla Model S he was driving collided with an articulated truck that turned left in front of his path. The car was running Autopilot, a beta program for semi-autonomous driving. The exact causes of the collision are still unknown, as investigators from the US National Highway Traffic Safety Administration, the US Senate Commerce Committee, and Tesla continue to gather and analyze data.

The tragic accident in Florida highlights that the technology for fully autonomous vehicles, in which “drivers” can completely disengage from events on the roadway, is still several years away. Furthermore, it will reignite the debate on the need for clearer legislation, as well as discussions around legal liability.

We believe, however, that this misfortune will not fundamentally alter the timeline or the business models we envision for the self-driving era.

August 2016
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The signature of our namesake and founder, Andrew Thomas Kearney, on the cover of this document represents our pledge to live the values he instilled in our firm and uphold his commitment to ensuring “essential rightness” in all that we do.