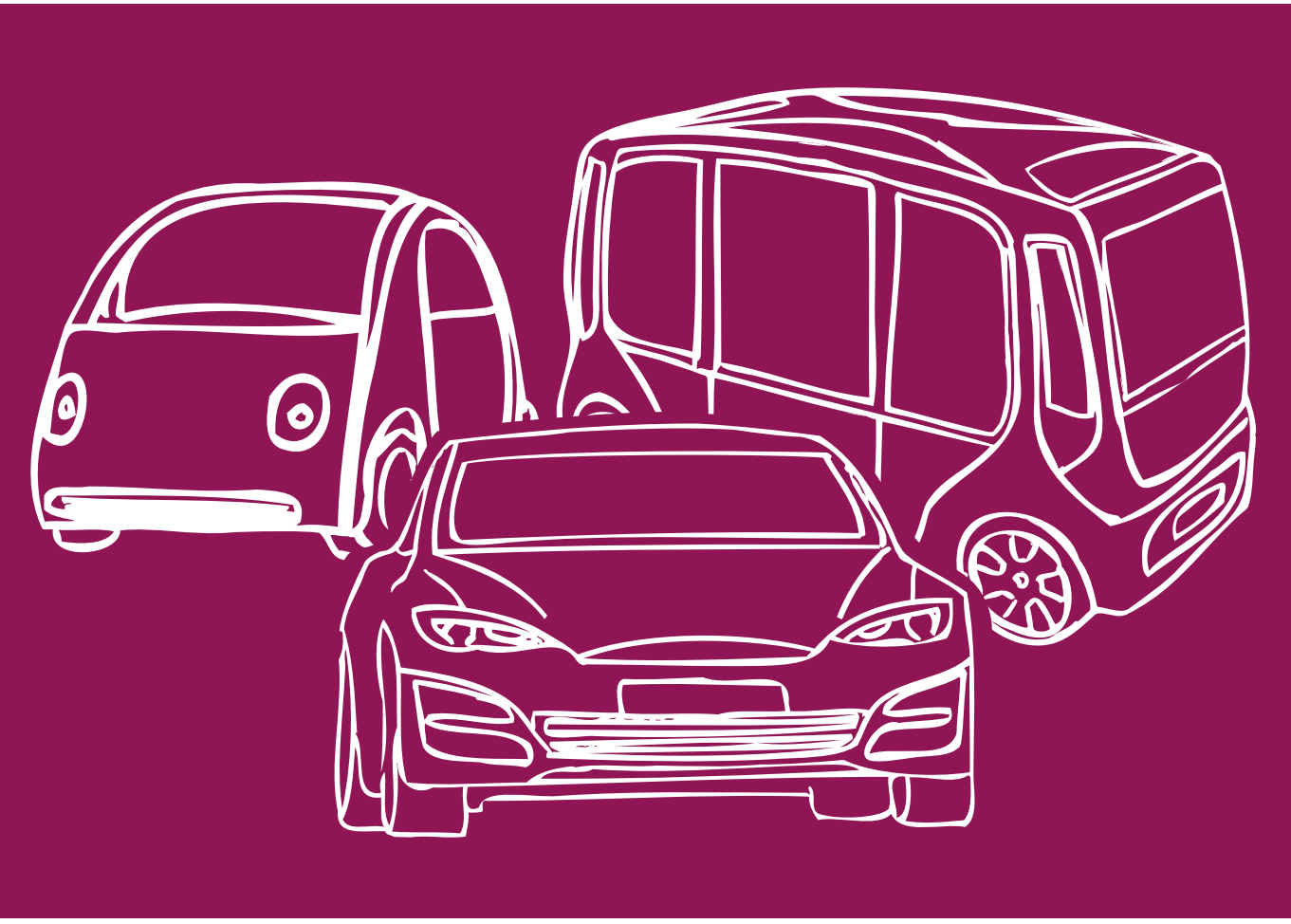
THINK ACT

BEYOND MAINSTREAM



AUTONOMOUS DRIVING

Disruptive innovation that promises to change the automotive industry as we know it — it's time for every player to think:act!

NOVEMBER 2014

Roland Berger
Strategy Consultants

THE BIG 3

1 Evolution

Autonomous driving is the future! Until 2030 however, the impact on the automotive industry is more or less evolutionary.
p. 6

2 Innovation

By 2030 the opportunity will be USD 40-60 bn, but the automotive industry has to master new capabilities and introduce new monetization models to tap into this profit pool.
p. 10

3 Revolution

The wide adoption of full self-driving automation after 2030 will cause a revolutionary change in the ownership, usage and design of vehicles, redefining power dynamics in the automotive industry if the incumbent players don't take action.
p. 20

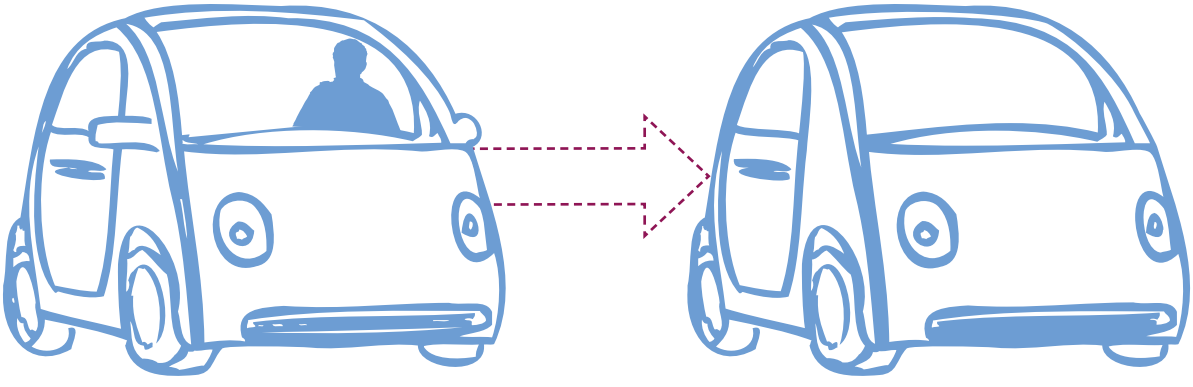
Application based designs p.18

Disruptive innovation in the making. While the revolutionary changes will come later, every player in the automotive industry has to answer key strategic questions for the road ahead.

Among the trends that are going to shape the automotive industry in the coming years, autonomous driving stands out as having the potential to completely change the automotive industry as we know it. Automakers around the world are unanimous in predicting the emergence of autonomous driving sometime in the next two decades and are making bold statements on how they plan to lead the charge in this newly evolving field.

While analysts may still debate the pace of change, the current state of autonomous driving technology or the power dynamics between incumbents and new entrants, there is no longer a debate over *if* autonomous driving is going to happen, but *when*.

For traditional players in the automotive industry, this means they have a series of strategic questions to answer that will determine the path to the autonomous driving future and their roles in it. OEMs and suppliers still have time to develop their strategies, but the clock is ticking. Automotive industry players have to act now to shape the autonomous driving future.



Autonomous driving is the future!
The combination of technology innovation, competitive forces, benefits and regulations are fueling this transformation.

Today, there are five key factors that are influencing the evolution of autonomous driving.

Technological innovation
Major automotive companies (Audi, BMW, Daimler, Ford, GM, Nissan, Toyota, Volkswagen, Volvo, etc.) and technology companies (Google, Induct, etc.) have already demonstrated autonomous driving through working prototypes and pilots. Several advanced driver assistance systems (ADAS) such as active lane keep assist, adaptive cruise control and self-parking are already available as combined functions on current generation cars. Additional functionality is expected to be rolled out in the next few years. Furthermore, significant efforts are being made to advance existing technology and to address cost-side challenges. Therefore, both the availability and affordability of key technologies to enable autonomous driving is expected to greatly increase in the coming years.

Competitive forces
The entire automotive industry is aware of the potentially huge market emerging from autonomous driving. Therefore, OEMs, suppliers and technology players are actively competing to claim their share of this revenue pool, positioning themselves for the future and using function-specific automation as a differentiator in the short term.

Individual consumer benefits
Several studies highlight the commute burden that people face today. In addition to long daily commutes to and from work, which take the average American 48 minutes per day, a recent study by the Texas A&M Transportation Insitute found that US drivers spend a total of 38 hours per year stuck in traffic jams for an annual cost of USD 818 per commuter. A large portion of this traffic in major cities constitutes drivers cruising in circles looking for parking. Autonomous driving addresses these and other driving pain points by reducing the commute burden in several ways: by removing the driving activity, commuters' in-transit time is freed up to pursue other activities such as working, reading, sleeping, watching TV or taking a video call; commuters' search for parking is eliminated, as they can be dropped off or picked up at an exact location – then the vehicle may go search for parking or serve other commuters in the interim.

Societal benefits
Autonomous driving could provide three major transportation-related benefits to society – decreased traffic congestion, improved road safety and reduced carbon emissions. The cost of traffic congestion is nothing short of astonishing. A 2011 study by the Texas A&M Transportation Institute estimates that urban traffic congestion caused Americans to travel an extra 5.5 bn hours and purchase an extra 2.9 bn gallons of fuel, putting the total congestion cost at USD 121 bn. An

analysis by Nationwide Insurance on the root causes revealed that over 70% of traffic congestion in the US are caused by bottlenecks, incidents and poor signals. These factors can be greatly reduced, if not eliminated, by autonomous driving.

In addition, according to the World Health Organization, road traffic injuries account for nearly 1.3 m deaths a year across the globe. In the US, the Department of Transportation estimates that over 90% of all accidents are caused by human errors, including speeding (32% of accidents), alcohol (21% of accidents) and distraction (17% of accidents). Autonomous driving could help prevent these accidents by eliminating the role of human error in driving.

Finally, transportation has a huge impact on our environment. In the US, the Environmental Protection Agency estimates the transportation sector is responsible for a staggering 28% of all greenhouse gas emissions, producing an equivalent of 1.8 bn metric tons of CO_2 every year. Other countries also show similar figures. Moreover, The Earth Institute at Columbia University estimates that autonomous driving can improve fuel efficiency by over 50% in some circumstances.

Regulation

Regulatory bodies across the globe are starting to pave the way for autonomous vehicles by developing the appropriate legal framework for vehicle testing and operation. In the US, where state legislation governs autonomous vehicles, Nevada, California, Florida and Michigan have already passed laws legalizing autonomous driving for various usage applications and conditions. At the federal level, NHTSA issued preliminary policy statements outlining safety guidelines for the development of autonomous driving technology and also released an advance notice of proposed rulemaking on developing vehicle-to-vehicle (V2V) communication that would facilitate autonomous driving.

In Europe and other countries that have signed the Vienna convention on road traffic, legislation is being altered in favor of promoting autonomous vehicle development. Until recently, the Vienna convention imposed that drivers must maintain permanent control of their vehicles. However, a recent amendment was made by the UN Working Party which permits autonomous driving as long as it can be overridden or switched off by the driver. Thus, a preliminary legal framework for partially autonomous driving already exists and serves as a basis for future regulations.

In Japan, the government started granting auto manufacturers special permission to test autonomous vehicles on public roads since 2013. In addition, the Japanese government is actively promoting R&D of autonomous driving technology through its Strategic Innovation Promotion (SIP) program in collaboration with various ministries, experts from academia, government agencies and industries. The government roadmap aims to introduce the practical use of V2V and vehicle-to-infrastructure communication by 2020 and fully autonomous driving by 2030.

1 The evolution has already begun.

Early autonomous driving features are already available, while full self-driving automation will be ready by 2025-2030.

A staged evolution

While the advent of autonomous driving is certain, we expect a staged introduction of autonomous driving functionality over the next 15 years A B. Today, many vehicles on the road are equipped through "Level 1: function-specific automation" with features such as cruise control and automatic braking. Advanced driver assistance features (such as adaptive cruise control combined with lane keep assist), referred to as "Level 2: combined function automation", are already offered by many established manufacturers.

A

STAGES OF AUTONOMOUS DRIVING
Autonomous driving classifications[1] and expected timeline

	Level 0	Level 1	Level 2	Level 3	Level 4
Degree of automation	**No automation** > Driver has complete control over longitudinal and lateral dynamics	**Function-specific automation** > Specific and multiple automatic functions are controlled individually > Example: Cruise control, automatic braking, lane keeping, etc.	**Combined function automation** > A minimum of 2 main steering systems are automated and operated simultaneously > Example: Concurrent use of adaptive cruise and lane keep assist	**Limited self-driving automation** > Designed so that the vehicle can operate safely while in automated driving mode > Driver can have the car control all functions related to safety	**Full self-driving automation** > All driving functions are automated and performed safely > All conditions are detected by the system; it is capable of returning to the minimum risk scenario
Driver's responsibilities	> Driver is responsible for the safe operation of the vehicle as well as monitoring traffic	> Driver is responsible for overall control and safe operation, but can delegate parts of the main steering system to auto-pilot	> Driver can delegate vehicle control under limited circumstances, typically with "hands-on-steering-wheel" > However, the driver is responsible for constantly monitoring traffic as well as safe operation	> Driver does not need to permanently monitor the system and traffic as long as the system is active; in the event that the system cannot maintain automated driving, the driver can safely take over	> Driver acts as a passenger – just needs to input the destination
Timeline	> Existing	> Existing	> Existing	> 2018-2020	> Low speed situations: 2020-2025 > Including complex operation: 2025-2030

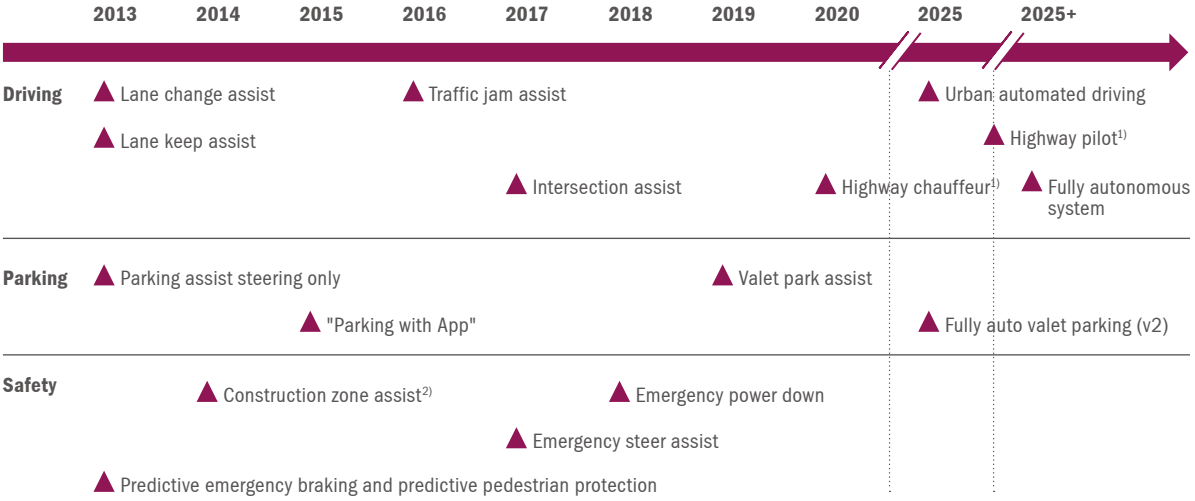
1) NHTSA (National Highway Traffic Safety Administration) classifies vehicle automation into five levels

Source: NHTSA, Roland Berger

B

EVOLUTION OF AUTONOMOUS DRIVING

Implementation timeline of selected autonomous driving functionalities



1) Highway pilot = Highway chauffeur + higher degree of automation; 2) Tested – date of series production not available

Source: Press research, conference proceedings, Roland Berger

Looking forward, we project "Level 3: limited self-driving automation" to be available by 2018-20 with features such as highway chauffeur (automated driving on highways). Furthermore, we expect "Level 4: full self-driving automation" to be first offered for low speed situations by 2020-25 (e.g., in parking lots or low-speed areas) and eventually, including more complex operations to be offered by 2025-30 (e.g., city driving).

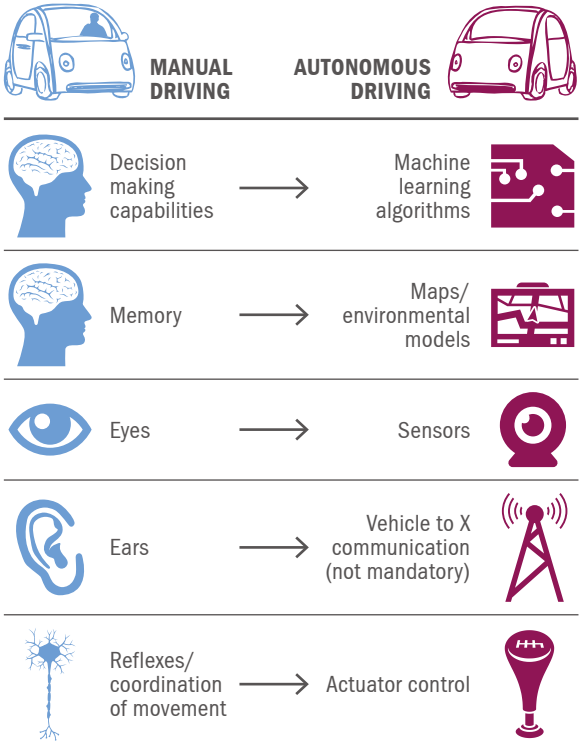
Even with the introduction of new technologies, we do not expect global adoption of full self-driving automation with "door-to-door" capabilities across all vehicle segments before 2030-40.

Technology to replace human senses. Removing the human from the driver's seat requires four key areas of mastery.

The lack of a human element in driving activity requires critical sensory functions to be performed using various technologies simultaneously C.

C

REMOVING THE HUMAN FROM THE DRIVER'S SEAT
Replacing sensory functions with technology



Source: Roland Berger

Many of these technologies already exist today. However, facilitating even "Level 3" functionality in complex traffic and driving conditions requires mastery in several areas D.

1. VEHICLE'S LOCATION AND ENVIRONMENT: As there would no longer be active human input for vehicle functions, highly precise and real-time information of a vehicle's location and its surrounding environment will be required (e.g., road signs, pedestrian traffic, curbs, obstacles, traffic rules).

2. PREDICTION & DECISION ALGORITHMS: Advanced concepts based on Artificial Neural Networks (unsupervised/deep learning, machine learning) will be needed to create systems to detect, predict and react to the behavior of other road users, including other vehicles, pedestrians and animals.

3. HIGH ACCURACY, REAL-TIME MAPS: Detailed and complete maps must be available to provide additional and redundant information for the environmental models that vehicles will use for path and trajectory planning.

4. VEHICLE DRIVER INTERFACE: A self-adapting interface with smooth transition of control to/from the driver, mechanisms to keep the driver alert and a flawless ride experience will be instrumental in winning consumer confidence.

D

CRITICAL CAPABILITIES TO ENABLE AUTONOMOUS DRIVING

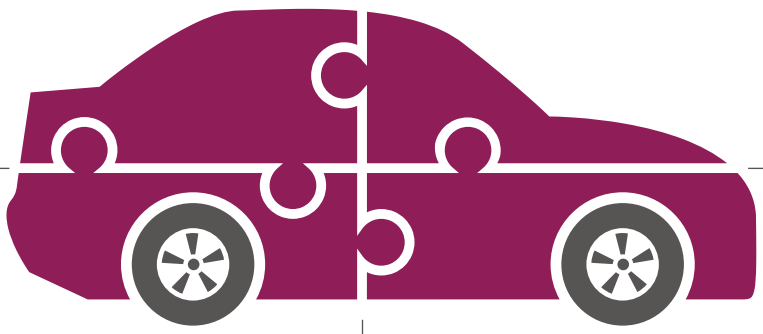
REQUIRED AREAS OF MASTERY

1 VEHICLE'S LOCATION AND ENVIRONMENT

- 3D Image processing with Artificial Neural Networks (ANN)
- Multiprocessor graphics hardware (GPUs)
- Current competency leaders: unmanned aerial vehicles, medical technology, videogames

4 VEHICLE DRIVER INTERFACE

- Smooth control to/from the driver
- Current competency leaders: advanced search engines, consumer electronics



2 PREDICTION & DECISION ALGORITHMS

- Artificial Neural Networks (ANN) (unsupervised/deep learning, machine learning)
- Specialized multiprocessor hardware
- Early, independent hardware validation based on Virtual HiL
- "Non-statistical" validation
- Current competency leaders: pattern/image recognition, automatic translation, voice recognition

3 HIGH ACCURACY, REAL-TIME MAPS

- Environmental/spatial modeling
- Simultaneous localization and mapping (SLAM)
- Current competency leaders: map provisioning, location-based services

Source: Roland Berger

2 Significant opportunities await.

By 2030, the new opportunities from autonomous driving will be around USD 40-60 bn, and that's just the start.

On the journey to mass adoption of full self-driving automation, we will see an evolutionary change in the automotive industry with several key implications.

Hardware components

The market for autonomous driving hardware components, such as cameras, sensors, communication systems, will – with the exception of "intelligent" cameras – most likely remain with automotive manufacturers and a core group of Tier 1 suppliers. By 2030, we estimate the entire market for new components to be around USD 30-40 bn E.

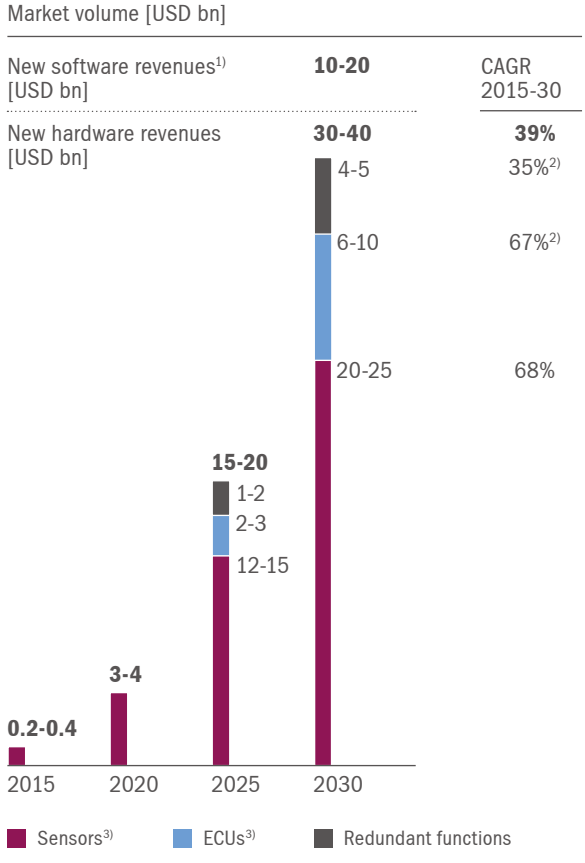
High accuracy mapping and prediction & decision algorithms

Two of the most critical elements of automated driving technology include new areas such as high accuracy mapping and prediction & decision algorithms. Both of these areas are mainly software-based and require large upfront investments in capital and time for development. Several major technology players already have a head start and therefore, are well positioned to lead the charge in these market spaces. By 2030, the market for this new software could reach USD 10-20 bn, depending on the business models applied E.

OEMs and full-scale system suppliers who are not yet active in high accuracy learning maps can still enter this space, but they have to make several key strategic decisions soon! Available options include making the upfront investments alone or establishing

E

ASSESSING THE MARKET SIZE
USD 40-60 bn market from new hardware and software



1) Prediction & decision algorithms; 2) 2020-2030; 3) Excludes cost of current ADAS sensor and ECU package, some of which will be made redundant by e.g., installation of a central master ECU

Source: Roland Berger analysis

alliances with other OEMs or technology players – we have already seen development in this direction earlier this year.

To develop "decision making" systems for automated driving, strong capabilities in the latest applications of Artificial Neural Networks (ANN) will be required. OEMs or full-system suppliers may choose to partner with research institutes or alternatively, form alliances with or acquire active players to quickly build the key competencies. OEMs and suppliers must act fast as this area is receiving increasing attention from other industries as well.

Monetization models

Young and technology-savvy consumers are most likely to adopt autonomous driving technology early. However, for the mass market segment, the additional USD 3,000-6,000 currently charged by premium OEMs for advanced driver assistance systems may create a barrier for adoption.

OEMs may need to rethink the business models for monetization of automated driving technology to foster quick adoption of autonomous driving. Suppliers also need to carefully evaluate technology priorities in order to focus on those technologies that can be monetized first.

OEMs may need to rethink the business models for the monetization of automated driving technology to foster quick adoption of autonomous driving.

Fortune favors the prepared.
To capitalize on the new opportunities, OEMs and suppliers need to prepare and take action today.

Key focus areas for OEMs F

With new players from technology and IT sectors entering, OEMs need to step up efforts to defend their position in the automotive value chain.

DRIVING EXPERIENCE

For more than a century, automotive manufacturers have mastered the overall driving experience, and they should continue to leverage this to their advantage. Even in the age of automated driving, the ride experience and vehicle control will remain very important to demonstrate comfort and safety. Furthermore, the vehicle's ability to adapt to driver expectations will be crucial for winning consumer confidence and acceptance.

PREDICTION & DECISION ALGORITHMS

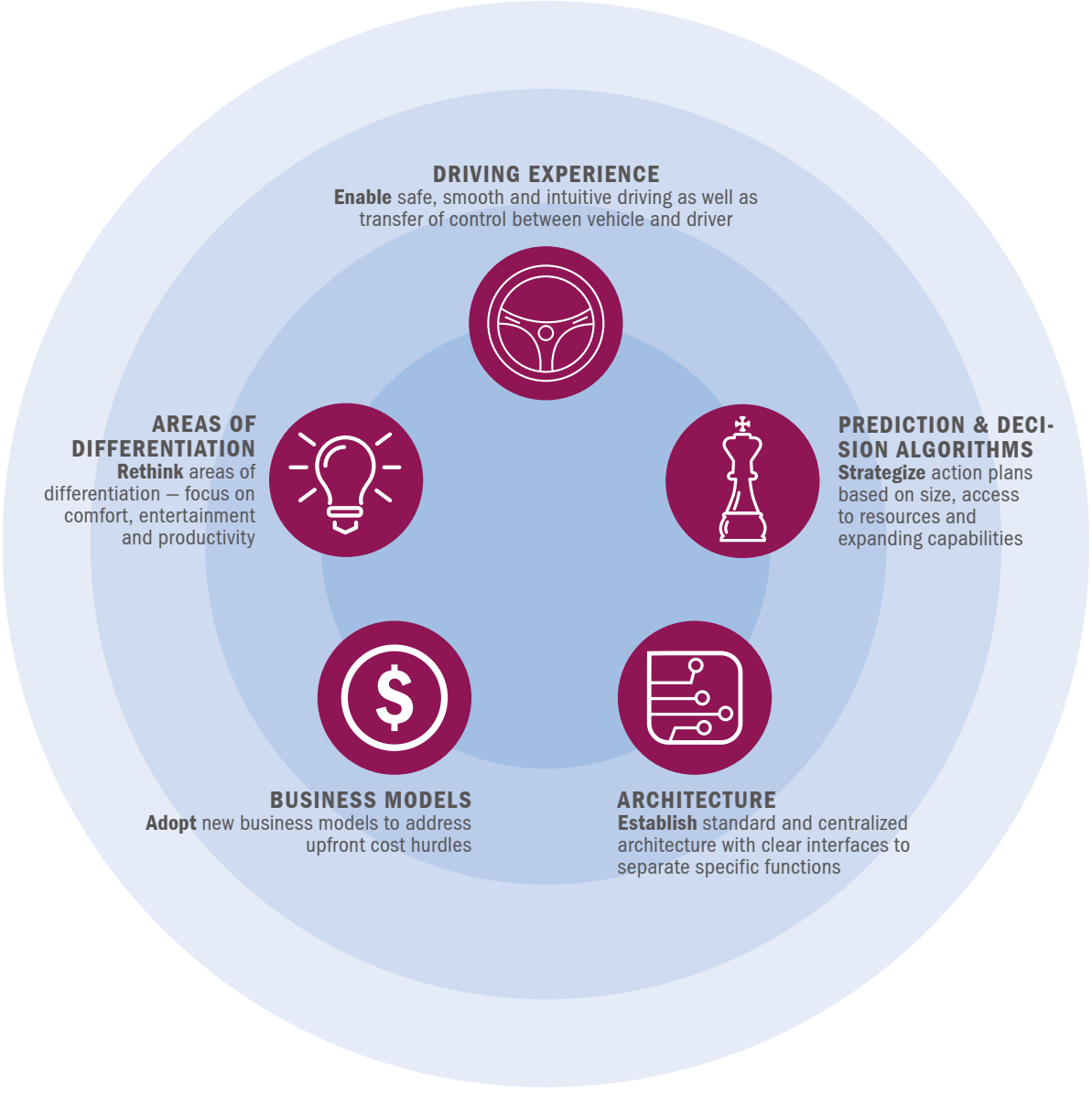
Considering the scale of investments required in the area of prediction algorithms, large and premium OEMs are best positioned to pursue building the required capabilities. OEMs should prepare and execute a strategy for developing prediction algorithms based on their respective sizes, access to resources and expanding core capabilities. To support these efforts, OEMs can leverage data from vehicles already on the road. Another important consideration is that OEMs should defend their position against new technology players who try to enter the market, through controlled access to vehicles and customers.

With new players from technology and IT sectors entering, OEMs need to step up efforts to defend their position in the automotive value chain.

F

FOCUS AREAS

OEMS NEED TO FOCUS AND ACT ON SEVERAL KEY AREAS



Source: Roland Berger

ARCHITECTURE

In order to choose the best suppliers for specific functions and to help system elements keep up with the quick pace of innovation (e.g., decision algorithms, electronics), OEMs should establish their own proprietary standards and central architectures with clear interfaces. This would allow for the independent separation of specific functional areas, which will become important for design validation, an area expected to be a major – if not the largest – cost component in the overall development of automated systems. Also, decoupling of hardware and software might allow for independent validation activities for control algorithms and derived hardware requirements, thus reducing time and costs. For example, OEMs could evaluate processing times of old vs. new hardware generations in simulated environments (Virtual HiL-type).

BUSINESS MODELS

OEMs need to consider adopting new business models to address the inherent affordability challenge for early adopters, to quickly increase the base of autonomous vehicle users and to maximize value captured. Lessons for new business models can be learned from other industries – examples include providing low upfront system prices for customers while OEMs leverage the data, offering pay-per-use mobility services or bundling autonomous driving features with other connected services.

AREAS OF DIFFERENTIATION

Finally, automotive manufacturers have to rethink areas of differentiation in the full self-driving automation world today. As humans no longer partake in the driving activity at this stage, driving dynamics will be less differentiating and hence will become less important. On the other hand, the commute time is now freed up to pursue other activities such as entertainment, work or rest. Therefore, ride and interior comfort along with productivity/entertainment features would gain utmost importance.

Automotive manufacturers have to rethink areas of differentiation in the full self-driving automation world, well in advance.

Key focus areas by supplier type

As the industry moves towards a more centralized architecture and automated driving functionality, a central electronic control unit (ECU) could replace multiple function-specific ECUs currently used for ADAS. As discussed, OEMs could try to build a core system with separate system elements to cherry pick the best solutions and to take advantage of the fast pace of other players' innovations. Considering these changes, suppliers need to act depending on their competencies in the autonomous driving space.

MAJOR SYSTEM SUPPLIERS PROVIDING FULL-SPECTRUM SOLUTIONS

Suppliers in this category should look to make major investments in prediction & decision algorithm technologies, including machine learning, and to actively screen specialists/start-ups with strong experience in "deep learning" capabilities as acquisition targets. This will allow these suppliers to participate and remain relevant for autonomous vehicles by offering innovative, complete solutions to smaller OEMs and by delivering highly safety critical systems (ASIL D level safety). Early cooperation with these smaller OEMs might also give suppliers access to real on-road data to build ANNs.

To prevent OEMs' push towards value chain decomposition, suppliers can emphasize liability issues that affect industry dynamics, while simultaneously working on their own architectural standards. However, given the huge investments required in the sector, we do not see room for more than three or four major global players in the long run.

SPECIALIZED SUPPLIERS ALREADY ACTIVE IN AREAS OF ADAS AND ACTIVE SAFETY

Suppliers of single assistance systems will face tremendous pressure from ongoing trends, such as the centralization of ECU architecture. Therefore, instead of focusing on functional innovation, these suppliers

Given the huge investments involved, there will only be room for three to four major players providing full-spectrum solutions.

should focus aggressively on cost and cater to the volume/budget segments of the market.

SUPPLIERS FOCUSED ON TECHNOLOGY INNOVATION

These players will need to focus on their technology, while simultaneously making required investments to attain a global top-3 position in their respective domains. This is the only way that they can ensure their positioning as technology leaders and also as Tier 1 suppliers. Examples of opportunities include greater functional integration of actuators to reduce cost, or on the camera side, a push towards low-cost hardware supported by Artificial Neural Network technology.

Instead of focusing on functional innovation, specialized suppliers should focus aggressively on cost and address the volume/budget segments of the market.

After evolution comes revolution. Full self-driving automation will fundamentally change vehicle ownership, usage and design.

Revolutionary change will come

While the changes discussed thus far are evolutionary, full self-driving automation will serve as a major tipping point, revolutionizing the automotive industry. Personal vehicle ownership will not become extinct, even in the long-term. However, vehicle ownership structures and vehicle designs will change dramatically.

With full self-driving capabilities, vehicles will be able to drive to a passenger, then after the trip, drive to another passenger or park themselves. We expect today's black car, taxi, ride sharing and rental car offerings to merge into one low-cost, driverless mobility-on-demand offering. With low cost and high convenience, mobility-on-demand could become an established and widely used method for personal mobility in cities, suburbs and for daily commutes. Arguably, this would not only disrupt current car-based mobility industries mentioned above, but also have an effect on the automotive industry itself.

With greater access and penetration of mobility-on-demand, vehicles will be designed with specific applications in mind, based on use cases and passenger needs. These designs could include:

1. Short-distance vehicles for inner city, inner suburb and last mile transport
2. Medium-to-long-distance vehicles for mixed suburb and city use
3. Multi-purpose vehicles for personal ownership

Figure G shows the profile of possible vehicle designs, and Figure H shows examples of use cases in various locations.

Short-distance vehicles would likely be used as part of a mobility-on-demand service. As most errands and commutes will be served by automated vehicles at low cost and high convenience, we expect the 2nd car per household to strongly decline. However, we expect vehicle ownership to still persist to provide for a more personalized travel experience and to meet certain consumers' need to express their individuality through vehicle ownership.

Fully automated mobility-on-demand fleets would become a major part of the car parc. The market structure will change from highly fragmented individual vehicle ownership to highly concentrated fleet ownership by mobility providers, with the effect of homogenizing this vehicle segment and significantly altering automotive business models.

Overall, there will be a lower demand for personal vehicles. However, we expect to see an increasing trend towards premium vehicles, as people seek to express their individuality through vehicle ownership.

G

APPLICATION BASED DESIGNS

EXAMPLES OF POSSIBLE VEHICLE DESIGNS

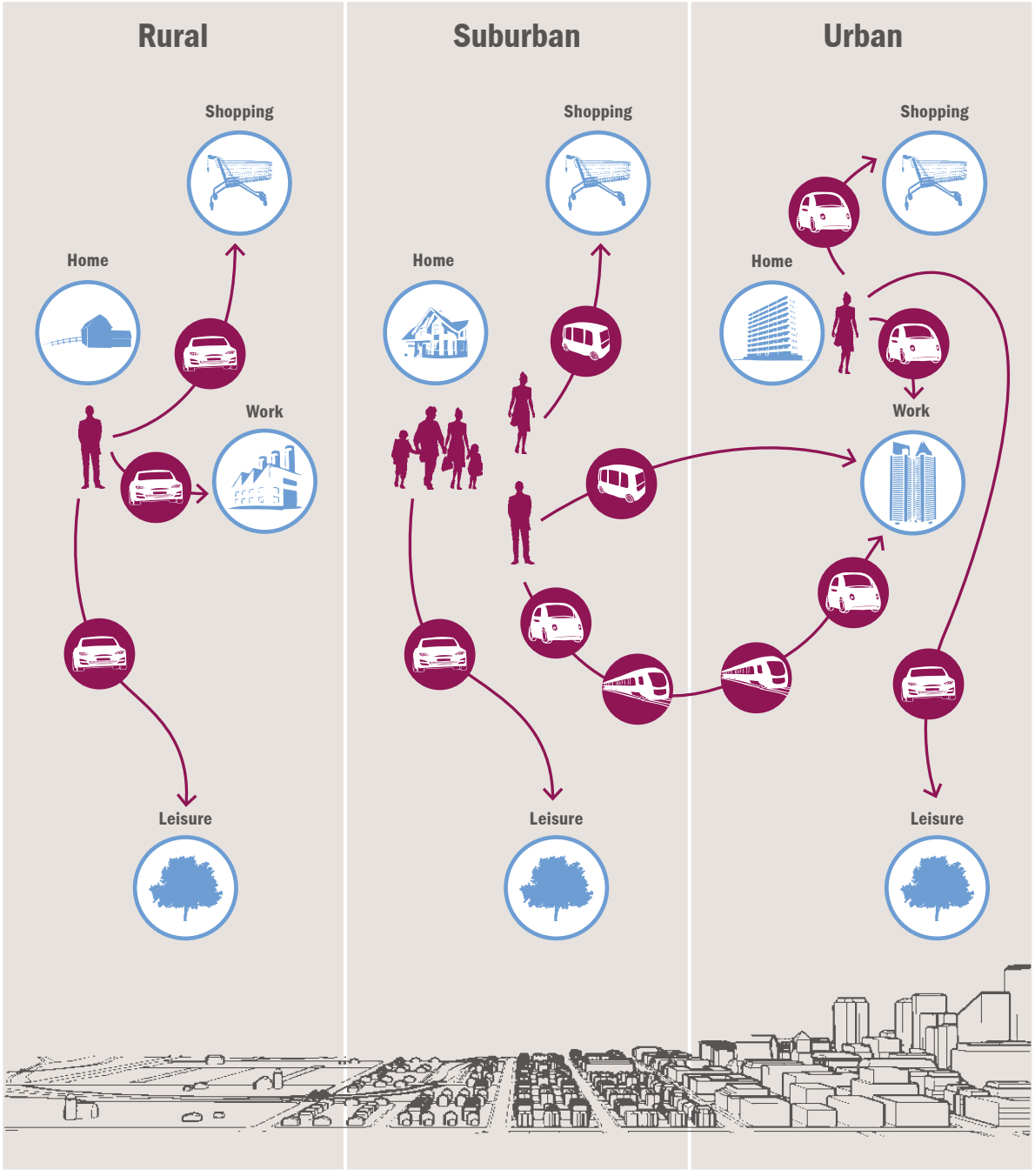
	SHORT-DISTANCE VEHICLE	MEDIUM-TO-LONG-DISTANCE VEHICLE	MULTI-PURPOSE VEHICLE
Primary uses	> Short trips within cities, suburbs or for last mile transportation to/from public transit such as the nearest subway station	> Medium-to-long-distance trips in suburbs and cities	> Personalized and/or leisure travel for multiple passengers
Primary focus	> Easy maneuverability and low cost	> Higher comfort for longer trips	> Personalized travel experience and comfort
Average trip distance	> Mostly under 10-15 miles	> Mostly over 10-15 miles	> Any range
Design	> Mini-vehicle	> Medium to large vehicle	> Medium to large vehicle
Capacity	> 1-2 passengers > Limited cargo space	> 4+ passengers > Large cargo space	> 1-4+ passengers > Limited/large cargo space
Ownership	> Shared mobility	> Shared mobility	> Personal ownership
Areas of use	> Cities and suburbs	> Cities and suburbs	> Cities, suburbs and rural
Important attributes	> Fuel efficiency > Low emissions > Low maintenance > Reliability	> Comfort > Fuel efficiency > Low emissions > Low maintenance > Reliability > Infotainment	> Individualization > Comfort > Online services > Infotainment > Fuel efficiency > Low emissions > Low maintenance

Source: Roland Berger

H

MOBILITY IN THE AUTONOMOUS WORLD

Examples of use cases in various locations



Short-distance vehicles Medium-to-long-distance vehicles Multi-purpose vehicles

Source: Roland Berger

3 Rebalance of power.
The ownership of customer relationships and key technologies could define the future power dynamics.

Changes in personal mobility preferences and the implications of key technologies, namely new prediction & decision algorithms, are the primary drivers that will shape the future autonomous vehicle ecosystem. Mobility preferences will dictate commuter preferences and vehicle ownership structures, while key technologies will determine which party in the value chain will capture a larger share of profits. Combining these two drivers reveals several "end game" scenarios – each with specific challenges for traditional OEMs and suppliers. For ease of analysis, we have divided the automotive future into personal vehicle ownership and mobility-on-demand I.

A. Personal vehicle ownership
In this space, prediction & decision algorithms would remain the only dimension of power balance, resulting in two possible scenarios:

SCENARIO A1: BUSINESS AS USUAL
Traditional OEMs and suppliers are able to fight off new technology players and develop inhouse prediction & decision algorithms. The future business models and relationships with individual vehicle owners will be largely unchanged.

SCENARIO A2: POWER TO THE TECH. SUPPLIERS
3rd-party technology players dominate the prediction & decision algorithms landscape, forcing traditional OEMs and suppliers to license the technology and be dependent on these players in the future. These 3rd-party technology players will capture significant share of the new value instead of traditional players.

B. Mobility-on-demand
In this space, both the dimensions (prediction & decision algorithms and mobility) influence the final power balance, resulting in four possible scenarios:

SCENARIO B1: BUSINESS AS USUAL
Traditional OEMs and suppliers develop the necessary prediction & decision algorithms and dominate mobility-on-demand with their own services. In this scenario, traditional OEMs would continue to leverage their brand value and retain end-customer relationships. With the exception of adding new mobility services, current business models in the automotive industry would be largely unchanged.

SCENARIO B2: POWER TO THE TECH. SUPPLIERS
OEMs dominate the mobility services space but technology companies dominate prediction & decision algorithms. In this scenario, OEMs would likely be-

come dependent on 2-3 technology companies providing prediction & decision algorithms. Therefore, OEMs' margins would come under pressure from the relatively small population of technology providers.

SCENARIO B3: FLEET BUSINESS 2.0

New entrants dominate the mobility services space, but OEMs dominate prediction & decision algorithms. In this scenario, OEMs' share of fleet sales to mobility services providers will rise significantly, increasing the importance of this sales segment. However, as mobility providers will be dependent on the technology of a few automotive OEMs, a new balance of power will be negotiated. Since a good portion of future vehicle sales will be "standardized" vehicles sold B2B, internal complexity and sales & marketing expenses will be reduced significantly. This could result in a net positive outcome for OEMs, even if vehicle prices are lower. Moreover, end users could benefit from reduced costs for mobility.

SCENARIO B4: OEMS BECOME TIER 1S

3rd-party ride sharing companies dominate mobility services and technology companies dominate prediction & decision algorithms. In this "worst-case" scenario, the role of traditional OEMs and suppliers may be reduced to that of contract manufacturers producing customized vehicles for mobility providers, while the largest portion of the profit pool goes to technology companies. This scenario would result in the greatest margin pressure and threat for traditional OEMs and suppliers.

I

END GAME SCENARIOS
Scenarios based on ownership of key technologies and customer relationship

OWNERSHIP OF CUSTOMER RELATIONSHIP

OWNERSHIP OF KEY TECHNOLOGIES	TRADITIONAL OEMS	NEW MOBILITY-ON-DEMAND PLAYERS
TRADITIONAL OEMS AND SUPPLIERS	**A1 B1 BUSINESS AS USUAL** > Traditional players remain in the driver's seat > OEMs are able to develop key technologies and leverage their brands to offer mobility-on-demand services > Technology development will be shared in cooperative partnerships similar to today	**B3 FLEET BUSINESS 2.0** > Significant increase in share of fleet sales to mobility providers – resulting in marketing cost reductions > New power balance as mobility providers depend on a few OEMs that control the key technologies > Combined effect could lead to higher OEM margins
NEW TECHNOLOGY PLAYERS	**A2 B2 POWER TO THE TECHNOLOGY SUPPLIERS** > OEMs will likely be dependent on 2-3 technology companies providing key technologies > OEMs' margins would come under pressure from the relatively small population of technology providers leveraging their bargaining power	**B4 OEMS BECOME TIER 1S** > OEMs could be reduced to contract manufacturers for the mobility-on-demand players > Could result in greatest pressure on OEM margins – biggest threat to today's mid-sized OEM players

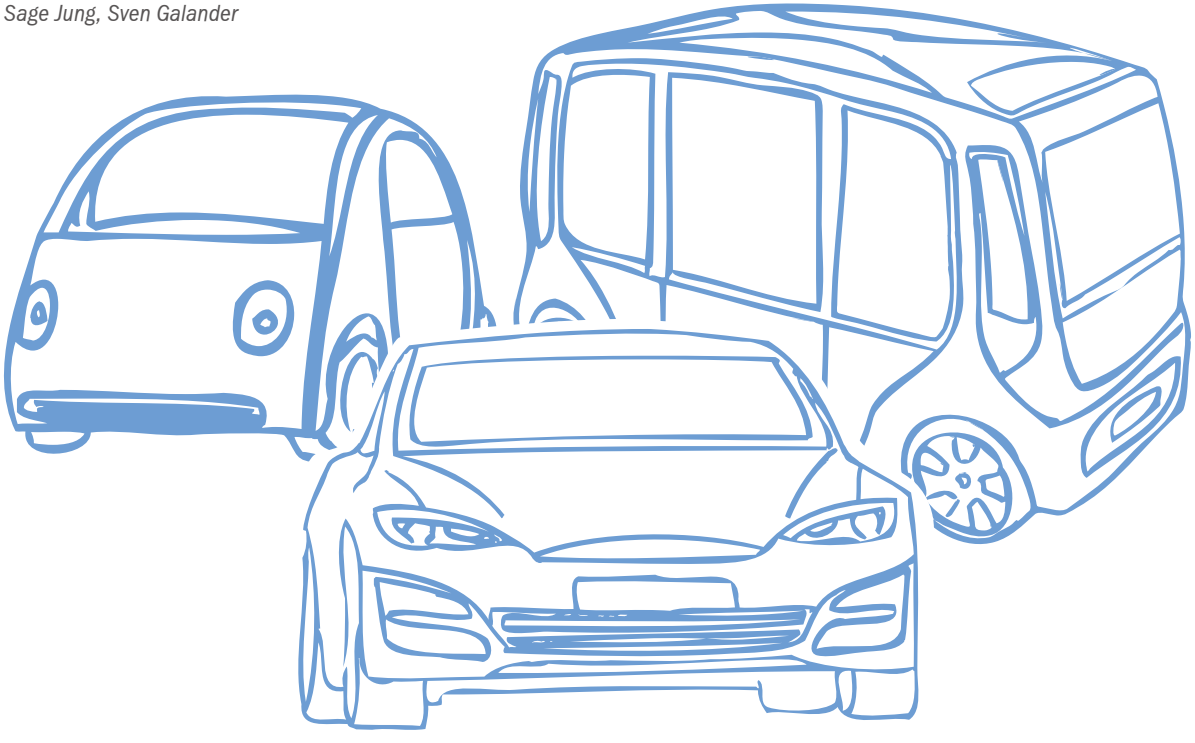
Personal vehicle ownership Mobility-on-demand

Source: Roland Berger analysis

Think:act now to shape your future! Careful analysis of future scenarios is required to define current action plans and to ensure a favorable future.

While there is money to be made during the evolutionary phase of autonomous driving over the next 15 years, OEMs and suppliers should prepare themselves for the revolutionary changes that will follow. The good news is that the train has not yet fully left the station. With scenario analysis, careful planning and concrete actions, the automotive industry still has a chance to *Think* and *Act* for a favorable future. ◆

Authors: Wolfgang Bernhart, Marc Winterhoff, Christopher Hoyes, Venkata Chivukula, Jens Garrelfs, Sage Jung, Sven Galander



ABOUT US

Roland Berger Strategy Consultants

Roland Berger Strategy Consultants, founded in 1967, is the only leading global consultancy with German heritage and of European origin. With 2,400 employees working from 36 countries, we have successful operations in all major international markets. Our 50 offices are located in the key global business hubs. The consultancy is an independent partnership owned exclusively by 220 Partners. **WWW.ROLANDBERGER.COM**

Further reading

SHARED MOBILITY

Shared mobility: where vehicles are shared and mobility offerings are used jointly will see rising revenues and growing customer numbers in the period through 2020. We anticipate annual growth rates of up to 35 percent in the new business fields around car, bike and ride sharing and shared parking. In a clear sign that this market trend is taking off, the number of market players in the segment is growing. Besides innovative start-ups, greater quantities of established companies like auto makers, transportation and logistics firms and airlines are entering the fray.

CONNECTED MOBILITY 2025

In the world's 30 biggest megacities, paralyzed traffic flows generate annual costs of more than USD 266 billion. The answer to gripping the problem of increasing passenger transportation lies with networked mobility. By intelligently linking transportation data and modes, people can quickly and easily use different mobility models as needed to get where they're going. Integrated offers and a comprehensive management function ("mobility manager") will play a central role by bundling various options and offering services from one platform. We defined five critical factors that will put smart mobility on the road to success.

CONNECTED VEHICLE

Networking is at last finding its place in the automobile. Information technology is progressing: Broadband connections, cloud computing and new data networks such as LTE now make fast data links between vehicles and the world a realistic possibility. Electromobility and new mobility systems such as car sharing and multimodal transport are facilitating the advance of the networked car. This development is forcing automotive engineering firms to rethink their business models and giving non-automotive players the chance to enter the market, too. That is why OEMs and suppliers must act now to consolidate their position on the market for networked automobility.

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Publisher

ROLAND BERGER
STRATEGY CONSULTANTS GMBH
Sederanger 1
80538 München
Germany
+49 89 9230-0
www.rolandberger.com

Roland Berger Strategy Consultants
71 S. Wacker Drive
Suite 1840
Chicago, Illinois 60606
USA

The authors welcome your feedback

WOLFGANG BERNHART, Partner
wolfgang.bernhart@rolandberger.com

MARC WINTERHOFF, Partner
marc.winterhoff@rolandberger.com

CHRISTOPHER HOYES, Senior Consultant
christopher.hoyes@rolandberger.com

VENKATA CHIVUKULA, Senior Consultant
venkata.chivukula@rolandberger.com

JENS GARRELFS, Senior Consultant
jens.garrelfs@rolandberger.com

SAGE JUNG, Senior Consultant
sage.jung@rolandberger.com

SVEN GALANDER, Senior Consultant
sven.galander@rolandberger.com