The Connected Vehicle Comes of Age

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The Connected Vehicle Comes of Age

Executive Summary
This year will mark a turning point for the connected car as it moves from the early innovation stages of prototypes to a more mainstream offering hitting show floors in mature auto markets around the world. If the significant flash and sizzle of “smart” cars at the Consumer Electronics Show in January is any indication, this space is about to be flush with activity as automakers like BMW, Mercedes Benz, Hyundai, Toyota and more work with an emerging ecosystem of hardware, software, and service providers to meet growing consumer expectations for their driving experience.

BMW and Samsung demonstrated features in the all-electric BMW i3 that integrate the in-vehicle infotainment system, next-generation sensor technology, and the BMW iRemote app running on the Samsung Galaxy Gear and Gear S smart watches. Using the app, drivers can get at-a-glance information and issue a multitude of commands to the i3, including an advanced self-parking system.

One factor pushing connected vehicles into the mainstream is the growth of the in-vehicle infotainment market. Consumers want the same access to content and services in their car that they have when sitting in their living room watching a movie on a tablet. The ubiquitous use of smartphones and tablets provides manufacturers more options in developing and delivering in-vehicle infotainment, and offers an attractive alternative to proprietary systems. Also, new developments in mood-recognition technology, location-based services, in-vehicle Internet access, and vehicle information hubs increase the versatility of vehicles as mobile consumer electronic devices.

In addition, multiple trends in Human Machine Interface (HMI) have created an environment that speeds the progress and consumer adoption of connected vehicles:

- Increased power of smartphones
- Wearable tech, such as smart watches, traction with consumers
- Secure, seamless, machine-to-machine mobile connectivity between devices provided by the GSMA Embedded SIM (eSIM) standard

The Internet of Things and the Connected Vehicle
At the 2015 Consumer Electronics Show in Las Vegas, references to the “Internet of Things” abounded. The promise of a world in which a galaxy of smart devices connect with human beings and with each other was everywhere; but it was in connected vehicles that attendees saw this vision brought to life most vividly and compellingly.

To truly be a “connected vehicle” automobiles—or two-wheeled vehicles such as smart scooters—must enable driver and passenger access to information, media content, cloud-based services and telematics.

Gartner states that, “...there are actually three levels of connectivity associated with infotainment systems:

- Connection to a wide-area wireless network using 3G or 4G LTE technology
- Connection to other systems within the car, such as rear-seat entertainment and Advanced Driver Assistance Systems (ADAS), over in-vehicle data networks
- Connection to smartphones and other mobile devices that are brought into the car, typically through a USB port, or wirelessly over Bluetooth or Wi-Fi connections”

The era of the connected vehicle will transform how consumers think of transportation. Though the concept of a car as a mobile device is not new, connected vehicle technology will make
it a reality. Mass acceptance of smartphones redefined the telephone in people’s minds to such an extent that its uses as a computer, a gaming device, a virtual shopping device, and a source of information and entertainment, have eclipsed its use as a means of voice communication. In a similar fashion, we expect to see a radical difference over the next several years in how consumers view vehicles. Their primary use will still be to transport people between two points—but that function will be one among many that are valued just as highly.

“By year-end 2020, Gartner predicts that 70% to 80% of all new vehicles sold in mature automotive markets such as the United States will offer connected-vehicle functionality.”

In the report, ‘Hype Cycle for Vehicle-Centric Information and Communication Technology (Vehicle ICT), 2014’, Gartner analyst Thilo Koslowski states that, “Connected vehicles are ushering in the era of smart mobility, which will turn automobiles into self-aware nodes on networks that can access, share and create digital information and, eventually, even gain self-driving capabilities.”

**Key Technology Trends**

Two key factors contribute to the current maturation of the connected vehicle. The first is the growth of the in-vehicle infotainment market. The second is a confluence of trends within the area of Human Machine Interface (HMI)—specifically the spread of smartphones, wearable tech and the Embedded SIM (eSIM) specification.

**Key Factor #1: The growth of in-vehicle infotainment**

According to research conducted by Gartner, “... the infotainment system market is poised for growth. Infotainment head units are a $1.7 billion semiconductor opportunity in 2014; this could double to $3 billion by 2017, representing average growth of 14% per year.”

During the early days of in-vehicle infotainment, automakers took an approach that leaned using vehicle-based HMI such as touchscreens, multifunction controllers and speech recognition. With the current ubiquity of connected mobile devices tech wearables, manufacturers are beginning to recognize the benefits of a Bring-Your-Own-Device approach that makes greater use of users’ tablets, smartphones and smart watches. Gartner has stated that if the in-vehicle BYOD trend becomes strong enough, “automakers could find that it makes more sense to accommodate the use of tablets in the car, rather than investing in development of proprietary infotainment systems.”

Other developments are fueling the growth of in-vehicle infotainment:

- Location-based services can use information about the coordinates of vehicles and users’ mobile devices to provide useful services, and offer relevant value propositions.
- The growth of in-vehicle Internet access is expected to speed the adoption of Internet radio in automobiles during the next five years.
- Vehicle information hubs provide an interface that enables users to safely access digital content and contextual information from any portable device or cloud-based application.
- While still in a mostly experimental phase, mood recognition technologies can sense the emotional state of a user and respond with appropriate predefined actions. Mood systems can adjust the environment in the vehicle through lighting, music or temperature to improve the driver’s mood, make him or her more alert, or impart specific information and suggestions. (For example, playing dynamic music to energize an exhausted driver, as well as verbally encouraging the driver to pull over and rest at the earliest opportunity.)

**Key Factor #2: HMI Trends**

In addition to the growth of in-vehicle entertainment, several trends in HMI are converging to drive the rise of the connected vehicle, including the increased utility and adoption of smartphones; advances in wearable technology; and the advent of the Embedded SIM (eSIM) specification.

**Smartphones** now possess greater processing power, more sophisticated touch controls, a wider variety of apps, and more robust connectivity—making them an attractive option for manufacturers seeking to extend the functionality of vehicles.

In addition, the growing adoption of the MirrorLink standard for vehicle/smartphone connectivity provides an opportunity to expand the market by providing a vendor-neutral, OS- and OEM-agnostic standard for car-smartphone connectivity. MirrorLink enables manufacturers to replicate an iOS, Android, Windows or Blackberry smartphone’s display on the navigation screen, and communicate user prompts back to the phone. This gives customers access to a seamless and more responsible connected driving experience, where they can continue their smartphone experience while keeping their
attention on driving. Other standards do not offer the same degree of flexibility: Apple’s CarPlay is only compatible with iPhones, and Google’s Android Auto only supports Android phones.

**Wearable technology**, once the provenance of early adopters and niche audiences (such as athletes), has entered mainstream awareness over the past year. Devices such as smart watches can link to smartphones and proprietary in-vehicle systems to display information at a glance, in a location and visual format that helps keep a driver’s attention on operating their vehicle safely.

**GSMA Embedded SIM (eSIM)** embeds a SIM card in the vehicle itself, establishing connectivity without the need for a smartphone. It provides a single, de-facto standard mechanism that enables the simple and seamless mobile connection of all types of connected machines—making possible new features such as automatically alerting emergency services and the insurance company when the vehicle is in a collision. With eSIM, manufacturers have access to secure, remote, over-the-air provisioning and management of SIMs in machine-to-machine (M2M) devices.²

The eSIM specification is expected to speed adoption of M2M services, and open up opportunities for new services and applications in connected vehicles, as well as a variety of industry verticals. In the U.S., eSIM equipped vehicles are already on the market. The European Commission has recommended that starting in 2015, all new cars sold in Europe should be fitted with an automatic in-vehicle emergency call service; by 2018, this will be mandatory.

**Connected Vehicle Use Case: Samsung and BMW**

At CES 2014, BMW became the first carmaker to demonstrate connected vehicle functionality using a smart watch. Via the BMW i Remote app on a Samsung Galaxy Gear smart watch, drivers could now stay connected with the all-electric BMW i3 using touch and voice, whether they were in the car or outside of it, without having to take out a smartphone and open the app. Current information on battery charge, available range and departure times were available at a glance, as well as whether the windows, doors and sunroof were closed. Drivers could also send a navigation destination to the vehicle, adjust the interior temperature, and locate where their vehicle was parked by verbally instructing it to honk its horn.³

The following year, BMW demonstrated new next-gen features in the i3 that took advantage of the Galaxy Gear smart watch. A new valet system enabled drivers to send a self-parking command to the i3 via smart watch; using high-definition sensors to map the environment, the vehicle could accurately and safely locate an available space. Using the same app, a driver could remotely summon the car from a nearby location, and even travel inside the vehicle as it drove itself at a safe speed, and for short distances.

**Summary**

2015 represents a turning point for visibility and adoption of connected vehicles, as they move more into mainstream production and show floors around the world. The industry will see growing consumer buzz about, and desire for, features that—while they may seem startling and science-fictional to drivers and passengers now—will soon become expected. The industry can expect to see the development of new products, including software and hardware, that take advantage of MirrorLink and the eSIM standard. Perhaps the most anticipated developments for consumers, though, will come in the form of disruptive services that leverage the convergence of wearable tech and in-vehicle infotainment. Smart watches are new entrants into the realm of mobile consumer electronic devices, and have the potential to transform the mobile experience for consumers by eliminating the inconveniences that come with the smartphone form factor. Always-on and always-connected will truly become a reality; and coupled with the in-vehicle capabilities of next-generation vehicles, will make the car much more than a set of wheels.

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1 Gartner RAS Core Research Note G00259577, 29 January 2014
2,3 Gartner RAS Core Research Note G00263255, 21 July 2014
4, 5 Gartner RAS Core Research Note G00258277, 29 January 2014
7 BMWgroup.com, “**BMW i Remote App a winner in the CES Innovation Awards 2015**”, BMW, November 11, 2014
Research from Gartner

Predicts 2015: Connected-Vehicle and Mobility Innovations Inspire New Digital Business Opportunities

Digital lifestyles, business convergence, self-aware vehicles and the Internet of cars will have fundamental implications for consumers, society, automotive organizations and other industries.

Key Findings

- Two primary groups of automotive organizations will emerge by the end of this decade: digital business creators and digital business participants.

- Digital data and machine insights are raising consumer expectations regarding the timeliness and accuracy in addressing and anticipating their needs. This emphasizes the importance of real-time and historic contextual information assets.

- By 2020, the number of connected passenger vehicles on the road in use will be about 150 million; 60% to 75% of them will be capable of consuming, creating and sharing Web-based data.

- The auto industry is evolving from the connected vehicle to the connected driver and to the connected consumer. This will result in industry convergence and new business opportunities for automotive companies, as well as for technology companies targeting the automotive market.

Key Findings

- Focus your digital customer interactions on identifying product, usage or general customer insights that can enhance the customer experience during the presale and ownership phase.

Strategic Planning Assumptions

In 2016, most automakers’ connected-vehicle content priorities will have shifted from general mobile applications to vehicle- and customer-specific services.

By 2020, 70% of all automotive-related customer touchpoints will be digital, leading to new customer experience metrics.

By 2020, at least one automotive company will achieve 10% of its total revenues from connected mobility and service offerings.

By 2018, two automakers will have announced plans to become technology companies and expand their connected-vehicle value experiences to other industries and devices.

Analysis

What You Need to Know

The automotive industry has the unprecedented opportunity to expand its century-old and so far undefeated value proposition of physical transportation. Connectivity technologies and the resulting “Internet of cars” are two critical elements that lead to this new opportunity. By leveraging digital business designs that center on converging automobiles’ physical benefits with virtual touchpoints and services, automotive companies can develop new value propositions. These new connected-vehicle and mobility offerings will center holistically on all aspects of a customer’s digital lifestyle and broaden the automotive industry’s offerings from a mostly product-centric core to a customer-experience-focused vision. This will ultimately pave the way for automotive companies to actively create industry convergence: the redefinition of industry boundaries by shifting the focus from individual products to cross-industry value experiences.

Recommendations

CTOs, CIOs, chief marketing officers (CMOs), CEOs, connected-vehicle executives and product planners at automakers, suppliers, and technology and service providers:

- Define your company’s long-term value proposition within the next two years, based on your desire to become a digital business creator or participant. Either choice is fine, but will require a focused technology and business strategy.

- Leverage existing application ecosystems for the integration of general mobile applications into vehicles. Refocus your resources on working with developers to create unique content and services that emphasize your product and brand values, as well as create new business opportunities.
The ability to benefit from these new digital opportunities rests on automotive companies’ creativity and ability to build dominant value propositions that embrace technology across all of their customer touchpoints and business partner interactions and within their own organizations. Vice versa, technology companies leading in the virtual world will have the opportunity to leverage digital business designs to expand into the physical world of transportation and mobility.

As a result, two primary groups of automotive organizations will emerge by the end of this decade:

- Digital business creators — Organizations that will have transformed into technology-centric businesses that deeply embrace digital value experiences in all their products, services, interactions and business model aspects

- Digital business participants — Organizations that will continue to operate primarily as a traditional, best-in-class product-centric company, and that let partners (or competitors) manage most (if not all) aspects of new digital business value propositions

Depending on the speed of the overall digital business progression, CEOs in automotive organizations will have to decide over the next two to four years which group they will want to join, since market realities and competitive forces will constrain a company’s options after that. The desire for creating new leadership in digital business areas will lead to higher investments, including venture funding, mergers and acquisitions, as well as partnership activities in the automotive industry — not just limited to startups, but also focused on established, large organizations in the technology space (for example, data analytics), mobility solution space (for example, traffic management) and content space.

### Strategic Planning Assumptions

**Strategic Planning Assumption: In 2016, most automakers’ connected-vehicle content priorities will have shifted from general mobile applications to vehicle- and customer-specific services.**

*Analysis by: Thilo Koslowski*

**Key Findings:**

- Connected vehicles serve Web-based content differently from other mobile devices, such as smartphones, to avoid driver distraction and to offer superior user experiences that take advantage of the automobile’s technology capabilities (for example, larger displays).

- The ability to differentiate a connected-vehicle offering and to create strong consumer appeal centers on unique input and output technology innovations, including cloud-supported user experiences.

- Furthermore, content directed at the connected driver must be targeted and contextual by enriching information with vehicle-, driver- and situation-specific data, as well as minimizing the risk of content duplication from other device platforms’ general mobile content.

- Most consumers’ current connected-vehicle experiences that are based on automakers’ proprietary systems have been lacking the functionality and intuitiveness of their mobile device experiences. Not surprisingly, 58% of all U.S. vehicle owners and 53% of all German vehicle owners agree that automakers should let technology companies like Apple, Google or Samsung design and manage their in-vehicle technology offerings, instead of developing their own systems.

**Market Implications:**

The increasing importance of human-machine interface (HMI) and cloud-supported user experiences will shift the automotive industry’s R&D focus to new technology and content innovations, such as gesture and mood sensing, consumer behavior analysis, and vehicle- and customer-centric services.
From a content perspective, this will mean a considerable shift:

- From the industry’s current focus on creating proprietary content platforms for integrating as many general mobile applications as possible that already exist on other mobile devices (that is, smartphones) ...
- To creating unique vehicle- and driver-related content and services that emphasize product and brand values and lead to new customer experiences

To facilitate this shift, connected-vehicle leaders in automotive organizations need to partner with existing ecosystems like Android Auto or Apple CarPlay that can simplify access to and integration of general mobile applications into the vehicle. This, combined with activities focused on creating unique and automotive-specific HMI and user experiences, will empower the automotive industry to leverage the unique benefits of an automobile (such as available physical space, knowledge of occupant positions and no power limitations) in creating unprecedented connected-customer experiences, which eventually will become more innovative and exciting than current smartphone and tablet offerings.

Recommendations:
CTOs, CIOs, CMOs, connected-vehicle executives and product planners at automakers, suppliers, and technology and service providers:
- Leverage existing application ecosystems for infotainment-centric, general mobile applications to free up resources from proprietary application platform activities. Use freed-up resources on:
  - Creating differentiated HMI innovations that center on how to enable customers to consume, create and share digital content in the vehicle
  - Joining forces with application developers to create specific applications for an individual automaker, such as a deeply integrated remote diagnostic application
- Explore how sophisticated vehicle and driver data analytics, combined with external customer and business data, can turn into new, differentiated content experiences for users and your marketers. This can even lead to new offerings that can be monetized — for example, becoming a new provider of traffic and weather data to third parties, such as traffic or weather information aggregators, and government agencies.
- Be mindful of customers’ data privacy and trust requirements, and always declare the use of collected data for the purpose of enhancing users’ customer experiences or benefiting the larger community. For example, consumers willing to collect traffic information on a regular basis could receive a discount on the vehicle’s registration tax.

Strategic Planning Assumption: By 2020, 70% of all automotive-related customer touchpoints will be digital, leading to new customer experience metrics.

Analysis by: Thilo Koslowski

Key Findings:
- Continued consumer adoption of smartphones, the mobile Internet, Web-based applications and the connected vehicle will give automotive organizations and consumers new communication options to interact with during the presale, sale and postsale phases.
- About 73% of all U.S. and 82% of all German vehicle owners generally leverage their mobile devices to use the Internet; about two-fifths of all U.S. and German vehicle owners spend more than one hour on the Internet a day on their mobile devices.
- Consumers’ information needs can be satisfied in real time via emerging mobile applications and services to request product and pricing information from dealers and manufacturers, and to post online used-car listings (for example, Beepi, Car Lister, Carvana and Openbay).
- The ability to remotely analyze diagnostic information can be used to automatically schedule service appointments by having users grant access to their calendars and preferences via machine tweets imitated by their vehicles.
• The monitoring of customer interactions and usage of in-vehicle features and their performance allows automotive companies to proactively engage customers when systems malfunction or certain features go underutilized.

Market Implications:
The availability of digital communication means will raise customer expectations regarding the timeliness and accuracy in addressing and anticipating their needs. This will require senior technology and business executives in automotive organizations to re-evaluate their customer-centric processes and ensure that service-department- or dealer-initiated communications leverage real-time and historic contextual information (for example, recurring performance problems with a vehicle infotainment system that have previously been addressed unsuccessfully).

Automotive organizations also need to ensure that they are balancing technology investments accordingly to accommodate the growth of digital customer touchpoints (for example, reducing spending on traditional call centers, providing access to cloud-based information to dealers, and moving traditional media budgets to marketing to customers directly via their infotainment systems). Access to real-time usage and performance data of in-vehicle features and systems will also lead to increased transparency regarding quality and warranty management aspects. Being able to act on these insights requires agile engineering processes and effective supply chain communications. Furthermore, some of the performance data will be of interest to legal bodies to ensure compliance with regulations (for example, emission requirements and recall data).

The sale and purchase of automobiles and parts and services via digital touchpoints will require automotive organizations and dealers to update and integrate their physical or virtual showrooms by leveraging, more frequently, technologies like augmented reality, virtual shopping, inventory uploads and interactive parts catalogues.

The growth in digital touchpoints via mobile devices and in-vehicle information and communication technologies will lead to a change in measuring customer experience, including its influence on customer loyalty. Rather than limiting customer experience to the resolution of a service issue, companies will need to define an experience metric that spans across as many digital customer touchpoints as possible to evaluate such dimensions as customer knowledge, usage patterns and preferences, and digital lifestyle level.

Recommendations:
CTOs, CIOs, CMOs, sales and customer service executives at automakers, dealers, and technology and service businesses:

• Focus your digital customer interactions on identifying product, usage and general customer insights that allow you to enhance the customer experience during the presale and ownership phase. Don’t make mobile marketing campaigns the center of your digital touchpoints — instead, with the customer’s permission, focus on functionalities and applications that increase the customer’s satisfaction and loyalty to your products and services.

• Adjust your technology and partner investments to capture real-time customer and product insights that can be shared across your internal and external stake holders. This includes, in particular, technology areas such as the capturing, storing and analysis of data, as well as providing access via Web services or applications to specific departments and individuals.

• Prepare your organization to take advantage of real-time, connected-product and connected-customer insights by enabling quick responses to new findings into your after-sales and services processes, as well as into the engineering department. For example, a user’s mobile application requests an urgent service appointment — it needs to be answered quickly and should be routed to a dealer that is near the user’s location — while a recurring performance issue with a vehicle component should also be communicated to the engineering department.
Strategic Planning Assumption: By 2020, at least one automotive company will achieve 10% of its total revenues from connected mobility and service offerings.

Analysis by: Thilo Koslowski

Key Findings:

• Vehicle sales are cyclical and correlate with overall economic factors — while consumers can delay automobile purchases, they require mobility regardless of the economic state.

• The continued growth of the mobile Internet, smartphones, sensors and shared assets exposes consumers to new digital service alternatives and business models that are increasingly influencing all aspects of their digital lifestyles, including the times they are mobile.

• By 2020, the number of connected passenger vehicles on the road in use will be about 150 million; 60% to 75% of them will be capable of consuming, creating and sharing Web-based data (for example, sharing location information and receiving wireless software updates on a regular basis) vs. those that can provide only one-way communication (for example, for eCall applications).

• The digitalization of automobiles, transportation and mobility are still in their early stages. However, current market responses and investments regarding ride-sharing companies like Uber and Lyft, which mainly focus on matchmaking demand and supply, are paving the way for additional, more comprehensive mobility innovations.

• About two-fifths of current vehicle owners in the U.S. and Germany would give up owning a vehicle if they could subscribe to an on-demand autonomous vehicle service.

• More than half of all U.S. and German vehicle owners can envision using an intermodal mobility service that compares the costs and times for a specific trip among various modes of transportation to select the best option to get them to their destination.

• The Internet of cars will be one of the first real product and industry examples of the Internet of Things. It will lead to innovations in the smart mobility and connected-vehicle space, such as the integration of home automation and connected vehicles (T. Koslowski, “Forget the Internet of Things: Here Comes the Internet of Cars,” Wired, 4 January 2013).

Market Implications:

Automobiles will continue to be the primary method of individual mobility in the future, and new technology innovations, such as self-driving vehicles, will further strengthen the automobile’s leadership position, much to the disadvantage of public transportation choices. However, personal attitudes toward vehicle ownership will likely change for a growing number of consumers as a result of pay-per-use and sharing economy trends that are enabled by mobile and remote-vehicle-access technologies. This will increase consumer awareness of alternative solutions centered on ad hoc personal transportation offerings to mostly augment and, in some cases, replace traditional ownership.

Enabling those alternatives will be new business models for using automobiles on an as-needed basis, such as community and member access to vehicle fleets that can be rented, as well as car-sharing services. In each case, vehicles and service offerings will leverage in-vehicle and external information and communication technologies to connect with consumers and other businesses, such as parking garage operators to automate payment. Eventually, a portfolio of well-defined mobility and connectivity offerings will empower automotive companies to create robust service revenues and create new market leaders.

Recommendations:

CIOs, CTOs, CEOs, aftermarket leaders and connected-vehicle product planners of automotive, technology and communication service provider companies:

• Prepare your business, product, marketing and technology efforts to address consumers’ expanding attitudes toward vehicle ownership and broader mobility needs. Define additional value propositions that augment or replace traditional vehicle ownership (for example, create subscription business models that give consumers the ability to drive a specific automobile brand or a range of different vehicles on a time-limited basis) and that encompass a wider variety of mobility offerings.

• Leverage vehicle-centric information and communication technologies (vehicle ICT) to enable ad hoc automobile access via user identification, remote monitoring, automated billing and insurance management.
• Align existing, internal and partner-based commerce processes and databases to take advantage of additional monetization opportunities that the connected vehicle can bring (for example, a content platform for information targeted at the driving customer, parking fees and fuel purchases). This also includes leveraging already existing capabilities within your captive financial services organization (for example, customer billing and payment information) or dealerships.

• Consider potential revenue sharing with consumer electronics and Internet companies that are extending their reach into the vehicle.

• Be bold and let your creativity run beyond preconceived boundaries. For example, the auto industry should have invented the smartphone as an extended interpretation of physical and digital mobility.

**Strategic Planning Assumption:** By 2018, two automakers will have announced plans to become technology companies and expand their connected-vehicle value experiences to other industries and devices.

*Analysis by:* Thilo Koslowski

**Key Findings:**

Virtually every automaker is rolling out connected-vehicle offerings across all four functional areas (telematics, infotainment, advanced driver assistance systems and mobility innovations) to address customers’ digital lifestyle convergence needs. Gartner predicts that, by the end of this decade, 70% to 80% of all new vehicle models being sold in mature automotive markets will offer standard or optional Internet connectivity technologies to enable the consumption of Web-based data inside the vehicle.

For automotive companies, in-vehicle technologies are evolving from the connected vehicle to the connected driver and, finally, to the connected customer. That means that information technology is becoming increasingly critical to all aspects of an automotive organization, including R&D, product development, sales and marketing, quality or warranty management, after-sales, and of course, in-vehicle technologies. In particular, automotive companies will continue to make investments and deepen their expertise in safety technologies, sensor information, self-aware sensing and driving capabilities, HMI innovations, and software optimization, as well as device, content and information management.

This shift to technology utilization across the entire automotive organization, its partners and customer touchpoints means that the success of future automotive organizations will hinge on companies’ ability to build successful technology ecosystems and to make decisions as a technology company. This will ultimately move some automotive companies to the point of making the decision to become a technology company that is focused on building highly sophisticated connected-vehicle value experiences that are centered on automobiles and/or mobility solutions.

**Market Implications:**

Passenger vehicles are not going to be extinct; on the contrary, new connected-vehicle offerings will expand the core value of automobiles from a means of transportation to a mobile device platform that offers unprecedented driving and mobility experiences.

By becoming a technology-centric product and service organization, automakers as well as other automotive companies will be able to expand their business focus and fight off competition from technology companies that are expanding their own reach from the connected customer to the connected driver and, ultimately, to the connected vehicle. In particular, automotive companies have the opportunity to move beyond a point-of-sale-centric vehicle sales business model toward a variety of monetization opportunities focused on the sum of the automobile ownership, driving experience and user-related aspects.

Furthermore, automotive companies could consider offering nonautomotive offerings that tie the connected vehicle into other connected-customer experiences (for example, home security and automation). This expanded business approach will allow the automotive industry to move from a product-centric value proposition to a focus on cross-industry value experiences and exemplify the concept of industry convergence — diminishing boundaries that previously described homogeneous industry sectors in which organizations conducted the majority of their business.
As automotive companies have the opportunity to transition into technology companies, technology companies will become more active in the automotive space, and some will eventually even launch their own offerings.

**Recommendations:**

Automakers’ and suppliers’ C-level business and technology leaders:

- Make a decision that will determine your long-term future as an end-to-end connected-vehicle ecosystem or as a simple “device” manufacturer. Over the next four years, automakers must either:
  - Embrace the changes and new growth opportunities. Embrace the changes and new growth opportunities that the connected vehicle will bring across all aspects of the business and throughout the entire partner network. This will require a commitment to building and owning a market-leading connected-vehicle ecosystem, strategy and customer experience, in addition to building the best vehicles.
  - Leave connected-vehicle opportunities up to other ecosystem partners that are better positioned to create successful connected-vehicle value propositions based on their expertise or resources. This will require a focus on building the best automobiles and becoming the preferred partner for technology ecosystem leaders.
- Envision the connected vehicle as the ultimate mobile device that offers new opportunities for product and brand value differentiation, and can lead to new connected-customer experiences even outside of the automotive marketplace. For example, the connected vehicle is the ideal communication platform for conveying customer service messages in real time and automating service orders. Yet it can also become the most sophisticated device that offers superior content experiences: For example, the large interior space of an automobile allows for a much more immersive and controllable media experience than a smartphone or tablet can (that is, by leveraging the windshield as a projection surface during autonomous driving).
- Realize that IT is the key enabler for new, connected-vehicle offerings and overall customer experiences. For example, automotive organizations must have deep expertise in vehicle ICT, cloud computing, mobile technologies and information management, and use this knowledge to optimize all internal and external activities and touchpoints. This means that automotive companies must attract technology experts across all business areas, and not just in the IT department, and prepare key executives and stakeholders for the transition into a technology company.

**A Look Back**

*In response to your requests, we are taking a look back at some key predictions from previous years.*

**On Target: 2010 Prediction** — Through 2014, connected-vehicle innovations will increasingly be influenced by nonautomotive companies, requiring new partnership models and value chains (see “Predicts 2011: The Automotive Industry Accelerates Innovations”).

This prediction is proving correct: Since 2010, major technology companies like Nvidia, Nokia, Apple and Google, which previously had limited focus on connected-vehicle offerings, have been actively pursuing the automotive industry. Furthermore, other technology and service provider companies like Microsoft, Intel, SAP, Atos, AT&T, Verizon and SiriusXM have expanded their automotive focus to specifically develop connected-vehicle offerings for the automotive industry. At the same time, new market entrants focused on mobility innovations have launched their offerings, such as Lyft, Sidecar, Uber and mytaxi.

**Evidence**

In a representative study conducted and analyzed in the first quarter of 2014, Gartner surveyed 2,185 adults in the U.S. and Germany who owned or leased an automobile, using an online survey to analyze consumer demand for vehicle ICT features and attitudes toward connected-vehicle options.

Gartner RAS Core Research Note G00270807, Thilo Koslowski, 12 November 2014
Maverick* Research: Crashing Industries and Our Societal Beliefs — The Real Implications of the Autonomous Vehicle

Self-driving vehicles will make us safer and more productive. More fundamentally, they will disrupt values, replace business assumptions and test our trust in smart machines. (Maverick research deliberately exposes unconventional thinking and may not agree with Gartner’s official positions.)

Key Findings

- Self-driving vehicles will evolve in three stages: from automated, to autonomous, to driverless vehicles. Only autonomous and driverless cars will lead to significant societal and business disruptions. The rise of self-driving vehicles will face market, technological and legal challenges.

- Nearly every organization with commuting workers, retail sites and physical deliveries will see the impact of autonomous vehicles on operational and staff productivity. Many industries and governments will have to adapt to new supply chains and redefined industry boundaries.

- Nearly two-fifths of U.S. and German vehicle owners are interested in autonomous vehicles, and would even consider giving up traditional vehicle ownership for having on-demand access to getting an autonomous vehicle whenever they need one.

- By 2030, autonomous-driving-capable vehicles will represent approximately 25% of the passenger vehicle population in use in mature markets.

Recommendations

Technology and business leaders in many verticals, including automotive, IT and communications, retail and commerce, energy and utility, insurance, parking, and government:

- Realize that self-driving vehicles are closer to realization than most people think, and that the implications aren’t limited to advancements in technologies and convenience benefits for drivers.

- Prepare for the fundamental change autonomous cars will have on your existing organization, employees, supply and distribution chain and internal operations. This includes leveraging the vehicle as a mobile office to increase productivity, ensuring mobile data security in vehicles.

- Expand your business opportunities by discovering new cross-industry value experiences that leverage autonomous vehicles to combine transportation value positions (for example, moving people and goods) with other service and product offerings (such as offering free shopping tours in an autonomous vehicle that picks up a customer at home to drive to the store).

Analysis

*Maverick Research

This is “Maverick” research, designed to spark new, unconventional insights. Maverick research is unconstrained by our typical broad consensus-formation process to deliver breakthrough, innovative and disruptive ideas from our research incubator. We are publishing a collection of more than a dozen Maverick research lines this year, all designed for maximum value and impact.

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The Renaissance of the Passenger Automobile

It’s the year 2030. The renaissance of the personal automobile in the era of smart mobility and technology-centric vehicles is in full swing as the preferred choice for sustainable and intelligent transportation — much to the disadvantage of public transit modes such as buses, trains and planes. One in four consumers has replaced vehicle ownership with access to on-demand mobility services that send an empty automobile to pick up passengers at their rural homes. This is ensuring mobility for everyone regardless of age or mental and physical capabilities. Connected vehicles monitor the state of all passengers at any time and drive them autonomously to the closest hospital in case of an emergency.
Urbanization has slowed to a crawl because “living far away from work” is no longer a determining consideration for home buyers. Supermarkets are offering “drive through and load” lanes for driverless cars that deliver products directly to individuals, while major retailers offer free self-driving shopping sprees that pick up customers at their homes to drive them to the nearby store and back home. Steel mills and auto insurance companies have lost half of their revenues since bumpers, steel-enforced crumple zones, airbags and accidents become a distant memory. Municipalities and law enforcement have shifted their focus from writing traffic tickets to identifying car hackers that turn cars into “rogue drones” that could threaten national security.

These future scenarios are not the result of eccentric daydreams. They are much closer to reality than most people and businesses realize. Over the next six years, self-aware vehicles will emerge that are increasingly able to autonomously sense, interpret, decide, act and communicate with other automobiles, infrastructures, businesses, people and organizations. As this self-awareness matures into the next decade, vehicles will become progressively smarter and autonomous. This will lead to the most fundamental change in transportation, mobility and society: the self-driving vehicle — the first pervasive, personal robots that most consumers will experience in their lifetime.

At the core of this change is not just the accumulation of hardware, software and data communication technologies. The real impact of self-driving vehicles is the disruption of our existing personal and societal beliefs and the reorganization of established business assumptions in many industries, including the financial services, retail and commerce, manufacturing, and services verticals. At the same time, self-driving vehicles will enable radically new digital business opportunities, such as personal delivery services that utilize a consumer’s driverless vehicle to transport packages between two businesses.

The following analysis focuses on the emergence, progression and implications of self-driving vehicles by providing a look into the future and by giving a pragmatic outlook regarding their realistic effects on people, societies and businesses, as well as the challenges that self-driving vehicles will face and eventually overcome.

**Characteristics of Self-Driving Vehicles**

A self-driving vehicle uses various technologies such as cameras and advanced driver assistance systems (ADASs), including the ability to keep a vehicle in its lane, to take over certain or all functions of operating a vehicle. Gartner differentiates three stages for self-driving vehicles, depending on the vehicle’s capability to augment or replace human operation and observation during the process of driving from a starting point to a predetermined destination (see Figure 1):

1. **Automated driving:** Certain vehicle driving functions are being executed by the vehicle itself, such as acceleration/braking and steering inputs during certain traffic conditions, but the driver is required at all times to keep in control. Vehicles with such capabilities are beginning to enter the marketplace, such as Mercedes-Benz’s new S-Class or BMW’s Traffic Jam Assistant feature.

2. **Autonomous driving:** All vehicle-driving functions are executed by the vehicle itself, but a driver still needs to be an occupant in the vehicle to intervene if needed. Automobiles with these capabilities are currently being tested on public roads in several countries (U.S., Germany, U.K. and Japan) by automotive companies (such as Audi, BMW, Daimler, Volvo, Toyota, Honda, Continental, Bosch, Denso and ZF/TRW) and technology companies (such as Google, Nokia Here, QNX, Nvidia, Intel and Verizon), as well as universities (for example, the University of Michigan and the University of Karlsruhe).

3. **Driverless driving:** All vehicle driving functions are being executed by the vehicle itself, and no driver or passenger needs to be present in the vehicle during operation. Such unmanned vehicles have also been tested, but only in controlled environments including off-road, closed courses (for example, on top of mines) and in parking garages (for example, by Audi, Valeo, Google, Rio Tinto, Stanford University and Carnegie Mellon University).
During the past few years, self-driving vehicles have received broad industry attention due to new efforts by established automotive organizations and technology companies. Most notably, Google’s first announcement from 2010 regarding its work on self-driving vehicles led to a broader media and consumer recognition of the future potential for automobiles, and highlighted the role of IT in enabling this vision. Today’s efforts that are focused on realizing the potential of self-driving vehicles are accelerated by these key trends (see Figure 2):

- **Technology advancements:** Improvements in sensor, positioning, imaging, guidance, machine learning and artificial intelligence (AI), mapping, and communications technologies, combined with advanced software and cloud computing capabilities, are increasing precision levels that are needed for self-driving vehicles to be used on public roads. The development of autonomous vehicles increasingly depends on sensor fusion, map data technologies and sophisticated computing platforms. For example, stereo cameras require high-speed data buses and high-performance computing processors to provide obstacle detection and analysis, as well as real-time route guidance.

- **Demographic and consumer preference changes:** In most mature automotive markets, younger consumers are increasingly putting digital lifestyle preferences over their desire for vehicle ownership or even obtaining a driver’s license. For example, new Gartner research shows that 34% of the 18- to 34-year-old U.S. vehicle owners would likely select Internet access over having a vehicle if they had to choose — versus 19% of drivers 45 years and older. At the same time, many countries are experiencing aging populations, which means that the number of potential drivers is shrinking. Self-driving vehicles can address both of these changes by enabling consumers to do other things while driving without having to worry about driver distraction and/or relying on the constant driver input. This, of course, raises legal and even ethical considerations, which will require the focus of industry leaders who want to make self-driving vehicles a reality.
• **New mobility solutions**: Self-driving vehicles will accelerate the current emergence of new mobility and transportation services (such as Uber and mytaxi) as an alternative to traditional personal vehicle ownership. For example, autonomous vehicles will eventually lead to new offerings that highlight mobility-on-demand access over vehicle ownership by having driverless vehicles pick up occupants when needed. Societal benefits from reduced accidents, injuries and fatalities and improved traffic management can be significant, and could even slow down or potentially reverse other macroeconomic trends. For example, if people can be productive while being driven in an autonomous vehicle, living near a city center to be close to work won’t be as critical. This in itself could slow down or potentially even reverse the trend of urbanization. In the long term, urbanization might become more attractive again because the adoption of autonomous and self-driving vehicles allows cities to reuse previously occupied parking spaces for recreation and homes.

In addition to these three trends focused on passenger vehicles, autonomous machine efforts in other industries (including the defense and commercial transportation sector, as well as law enforcement and entertainment) are also accelerating progress in key technologies needed for self-driving passenger cars.

**Self-Driving Vehicles’ Benefits, Implications and Disruptions**

The benefits of self-driving vehicles for individuals are significant, and range from accident avoidance, to optimized energy and traffic utilization, to improved compliance. It is critical to note that all of these benefits can be realized at meaningful levels even only with the realization of the first stage of sophistication for self-driving vehicles: automated vehicles. However, only autonomous and driverless vehicles — the second and third stages of self-driving vehicles — are capable of achieving the fundamental disruption at the societal and business levels that will permanently impact our beliefs and replace existing business assumptions with new ones (see Figure 3).
In the aggregate, the financial economic and societal benefits of self-driving vehicles can be astonishingly substantial. In a report from May 2014, the U.S. National Highway Traffic Safety Administration (NHTSA) reported that in 2010 automobile crashes — most of which were caused by human error — resulted in 32,999 fatalities, 3.9 million nonfatal injuries and 24 million damaged vehicles.

In the U.S., the economic and societal harm of automobile crashes amounted to a total of $871 billion dollars in 2010. This includes $277 billion in economic costs loss (such as loss of vehicle assets, loss in working productivity, and so on) — nearly $900 for each person living in the United States or 1.9% of gross domestic product (GDP) based on calendar year 2010 data — and $594 billion in harm from the loss of life and the pain and decreased quality of life due to injuries.

In addition to the opportunity and responsibility of significantly reducing accidents to save lives and avoid monetary consequences, autonomous and driverless vehicles, in particular, have fundamental implications on other societal values and economic dimensions: mobility for everyone, the impact on established professions, and new uses for personal productivity in automobiles.

According to a report by the World Health Organization from 2013, the total number of road traffic deaths worldwide remains high at 1.24 million per year (see WHO report).

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### Societal Implications

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Today, nearly 75% of these costs are paid through taxes, insurance premiums, and congestion-related costs such as travel delay, excess fuel consumption, and increased environmental impacts. These costs, borne by society rather than individual crash victims, totaled more than $200 billion (see NHTSA report).

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### Mobility for Everyone Will Democratize Transportation

A key attribute of fully autonomous (including driverless) vehicles is the fact that they enable people to travel in an automobile without the need for human intervention. This means that more people than ever before, including the elderly, children and the impaired, will be able to use passenger vehicles to gain vehicle-enabled mobility earlier in their lives or to regain it in their later lives.
For example, children who are too young to own a formal driver’s license could still benefit from the transportation value that an autonomous vehicle would provide for dedicated transportation scenarios. This would allow parents to have their kids brought home from school without having to make changes to their own schedules. The ability for a car to drive itself can also make automobiles more attractive to consumers who are eligible for a driver’s license, but who are not interested in obtaining a license due to other lifestyle priorities and the perceived lost time of having to operate a car. In this case, the autonomous vehicle will still fulfill its primary function of moving an individual to a specified destination using a personal means of transportation, but will allow the person to spend the time on other things (for example, reading email or watching a movie).

Another group of people that will benefit from autonomous vehicles are the elderly and impaired, who often have physical or mental limitations that interfere with their ability to operate a vehicle manually. According to the Organisation for Economic Co-operation and Development (OECD) the percentage of the population aged 65 years and older in its 34 member countries is expected to grow from 15% in 2010 to 27% in 2050. In individual member countries, this growth trend is even more significant (see the OECD “Health at a Glance 2013” report, page 54):

- In Japan, the percentage of people 65 years and older is projected to grow from 23% in 2010 to 39% in 2050.
- In Germany, the growth is projected to be from 21% in 2010 to 33% in 2050.

Autonomous vehicles will allow this group of the population to remain physically mobile over long distances, which will increase the individual’s and family’s quality of life and potentially allow older people to remain socially and economically active.

Furthermore, autonomous vehicles could provide a mobility option to groups in the population where individual driving is prohibited due to cultural or religious reasons, as in Saudi Arabia and other Gulf states.

### Autonomous Vehicles Change Professions and Impact Employment

Some professions will likely see long-term impacts from the rise of autonomous and especially driverless vehicles. In particular, passenger- and commercial-transportation-related work including car rentals, taxi and truck drivers will see competition in the form of smart vehicles that can take over many operational functions that humans currently perform. However, this does not necessarily mean that all of these professional drivers will become obsolete. Instead, they will likely shift their focus to adjacent and new skills, such as expanding into concierge-type functions (for example, not just driving a customer to a restaurant but instead identifying a suitable restaurant and entertainment options) and/or broader operational tasks (such as not just hauling a truck and its load to a destination but also booking and scheduling the next delivery job).

Public transportation services are also likely going to feel the impact of autonomous vehicles, especially when the latter can be offered as a cost-effective service that provides more convenience and personalization at equal or even lower cost.

Fewer accidents and injuries would also mean that automobile repair and body shops, parts manufactures and even dealers, automakers and suppliers would see less demand for their services and products, with likely implications for their staff. A dramatic reduction in vehicle-related injuries would also mean that hospitals, surgeons, pharmaceutical companies and insurance providers would see lower demand for their services. This could even impact the availability of donor organs.

Self-driving vehicles will also likely reduce the importance of municipal government activities by offering affordable transportation in the form of self-driving taxis for the less affluent, and hence eliminate the need to run costly transit operations. Furthermore, lower-density countryside living could result in the reduction of crime and other negative externalities that urban planning and city governments typically are confronted with. Highway police resources will likely be reduced and refocused on data communication and software security to ensure
the smooth operation of autonomous vehicle networks and to avoid the threat of vehicle hacking, new forms of theft (for example, cargo trucks being remotely hacked into and diverted) and “corporate cyberwarfare” that will tamper with companies’ businesses (such as directing autonomous taxis to take the longest route to upset customers and send them to the competition).

The emergence and growth of autonomous vehicles will mean that more people will be using passenger vehicles for their own transportation than it is the case today. This will lead to higher utilization of the existing road infrastructure and potentially higher maintenance investments. However, it does not necessarily mean that more vehicles on the road at a given time would cause new levels of traffic management complexities, since a key attribute of self-driving vehicles is their ability to communicate among other vehicles to improve traffic flow (for example, closely driving together at higher speeds).

Self-driving vehicles are likely also going to create new employment opportunities. The increase in the ability to be driven farther, cheaper and faster will expand the available area in which workers can apply for jobs. For example, for an employment-seeking person living in the inner city, there could be many jobs that they qualify for in the suburbs. Currently, they may not be able to afford their own car and transit could be too slow, preventing them from taking these jobs. Additionally, owners of autonomous and driverless vehicles could start new innovative businesses on their own. For example, they could make their vehicles accessible to transport other people or to deliver goods for nearby businesses where established logistics companies lack a presence.

Business Implications

Occupants of autonomous vehicles represent one of the most captive audiences available, which will create new target group opportunities for service providers, marketers and employers, and no longer just for media and broadcast companies. According to the U.S. census data from 2009, commuters spend an average of 48 minutes on their daily commute in their vehicle. The appeal of this global captive audience is one of the main reasons many nonautomotive companies are interested in and investing in autonomous vehicles. This desire will motivate technology companies to take an even more active role in developing autonomous vehicle solutions in the future. In 2011, Gartner predicted that by 2016, at least one megatechnology company will have announced plans to develop its own automobile offering.

The emergence of the autonomous vehicle and supporting technologies such as artificial intelligence will ultimately have business implications for numerous industries, redefine existing product and service offerings, and create new value propositions and business models. For example, artificial intelligence and consumer robotics are even used in toy applications. Anki Drive by Anki uses these technologies to create a computer-controlled autonomous slot-car-type game in which players fight against the computer to win the race. Another example is Knightscope, which leverages self-driving vehicle and data analytics capabilities to create the first autonomous crime prevention solution for the private and public sectors.

Existing Industries Will Be Redefined and Some Will See Obsolescence

Virtually every industry relying on the transportation of people and goods will be impacted by autonomous vehicles at some point, as workers can be productive while being driven in a “mobile office” and products can be loaded and delivered without the same level of human oversight that is required today. For many verticals, this will mean that their supply chains will be completely restructured. Just-in-time inventory management will leverage self-driving cars as a means of delivery, which will reduce the need to store products and thus result in fewer warehouses. Much of companies’ inventory may be circling on roads in packs of autonomous vehicles waiting to deliver the goods to end-customers’ doorsteps (with routes and locations selected by predictive analytics based on order and consumption histories). Autonomous vehicles will continue the automation benefit that warehouse robots provide, and owners of such vehicles (or in-car bots) will pick up the products from the warehouse. The disruption of existing value and distribution chains will even lead to the creation of new companies and potentially new industry segments that will leverage the capabilities that autonomous vehicles will bring.
However, some industries will see additional fundamental consequences that will potentially shift focus areas and impact their business outlook. The following list provides examples of industries and organizations that will be impacted by the rise of autonomous vehicles and offers instances of how their focus might change:

- **Energy and utility industries**: All stages of self-driving vehicles will be more fuel-efficient because they operate more steadily and can adjust their driving to road and traffic conditions that are beyond the visible range of a human driver (such as through the use of intelligent transmission and engine management software that can adjust parameters based on the actual number of other vehicles surrounding the car, and the traffic ahead).

- **Governments and parking industry**: In addition to substantial cost avoidance opportunities from the reduction of accident-related injuries, road repairs and traffic congestion, governments could also save on recurring infrastructure investments. For example, public road infrastructure and parking investments could get scaled back as autonomous vehicles communicate with each other, reducing the need for street signs and traffic lights and even saving on energy. Since driverless vehicles could become shared assets that pick up multiple users throughout the day, fewer parking spaces would be needed.

- **IT and communication industries**: At the center of autonomous vehicles is the need for critical technologies, including sensors, high-performance processors, software, and wired and wireless data communication. The importance of these technologies will continue to grow, although their priorities might change. For example, in 2013 Gartner predicted that by 2016, autonomous vehicle technology leadership will shift from sensor capabilities to highly detailed, rich map data and network-centric cloud computing innovations. The growing sophistication of self-driving vehicles means that technology companies will see an increase in technology demands per vehicle for the majority of all vehicles in mature global markets. This will elevate some technology companies’ roles in the automotive value chain to that of a Tier 1 supplier, or potentially even the go-to company for a complete product offering.

- **Insurance industry**: Since one of the key advantages of driverless vehicles is the reduction and potentially even the elimination of traffic accidents, vehicle insurance providers will likely suffer. A likely refocus will be on providing product-centric offerings that ensure the reliable operation of the vehicle and provide coverage if the system doesn’t perform to specifications. It is too early to tell who might actually pay for such an insurance coverage, since it could be the technology companies building the technology, the automaker selling the car, or even a government creating a no-fault budget for such incidents. Lawmakers are likely going to address these questions, as existing responsibilities and laws are inadequate to address the realities of autonomous vehicles.

- **Retail and e-commerce industries**: The delivery of products ordered online could be made via an expedited service offering by an autonomous fleet of driverless vehicles that are either owned by the company or rented from its employees or customers. Retailers might even send vehicles to customers who want to do personal window shopping at an actual store and then return them to their home. A similar offering — although not centered on an autonomous vehicle — was just introduced by NBC Sports, which partnered with the transportation company Uber to offer soccer fans free rides in vehicles that promoted the network’s coverage of the U.K.’s Barclays Premier League season.

- **Automotive industry**: Probably the biggest implications of self-driving vehicles are for the automotive industry itself. At the point where most vehicles on the road would be autonomously self-driving, certain aspects of the automotive product development aimed at vehicle safety can be simplified as crumble zones, hardened steel and passive safety technologies like airbags become less needed and potentially even unnecessary in an ideal scenario of 100% penetration of autonomous vehicles. Recent industry announcements and acquisitions underline a beginning to the realization of these impacts and a change in corporate strategy:
• Autoliv, one of the leading suppliers of passive safety technologies such as airbags, continues to expand its strategic focus to active safety technologies that support self-driving vehicle advancements (such as camera sensors) to be able to react to the “unpredictable” implications of the technology on its business. Sales of the company’s active safety products quadrupled from $85 million in 2010 to $345 million last year.

• In one of the largest acquisitions in the automotive industry’s history, supplier ZF Friedrichshafen of Germany agreed to acquire U.S. company TRW Automotive Holdings for about $13.5 billion to turn the new company into a “major player in autonomous driving technologies.”

Another impact for automakers is that consumer values from automobiles will change with the introduction of self-driving vehicles. Classic product differentiation based on horsepower as a means to faster driving might be replaced by the purchase of government-accepted certificates that entitle customers to go faster than other cars by using dedicated lanes and/or operating an autonomous vehicle at higher speeds. Additionally, automakers will need to focus on creating innovative interiors that are aimed at providing unprecedented connected experiences. This might require collaboration with interior design and even furniture companies. Automakers will also have to intensify their activities and investments in required technologies. For some automotive companies, such investments might go beyond their financial capabilities which will open the market for new entrants, including those from leading companies in other industries, such as Google.

The Emergence of New Business Models and Mobility Solutions

As self-driving vehicles become more sophisticated, automotive and other companies will be able to explore new business opportunities via partnerships that center on the use of complementary services that users leverage during vehicle operation, including Internet connectivity, media consumption and communication needs. This shift in consumer behavior to non-driving-related tasks in a “distraction safe” mode can lead to the introduction of new purchase and billing models that emphasize the longer-term customer engagement over the initial point-of-sale of an automobile:

• For example, in a recent Gartner study, 45% of all German vehicle owners responded that they are “likely” or “very likely” to sign up for an eight-year wireless-data-plan contract with their preferred network operator if in return they were offered a discounted price for their next vehicle purchase.

• Among U.S. vehicle owners, 39% are “likely” or “very likely” to sign up for such an offering.

Autonomous and unmanned driving modes in particular will also accelerate the growth of new smart mobility solutions that are not tied to the traditional vehicle ownership paradigm and instead are centered on on-demand vehicle access. Gartner’s research shows that some vehicle owners are ready to embrace the idea of replacing vehicle ownership with on-demand access as an alternative:

• 23% of U.S. vehicle owners are “likely” to forgo buying or leasing an automobile and instead subscribe to a service that offers them an autonomous vehicle on-demand.

• In Germany, 44% of vehicle owners are “likely” to give up personal vehicle ownership for such an alternative.

Figure 4 summarizes the consumer responses regarding new business and mobility solutions.
Challenges for Autonomous Vehicles

Despite the societal, economic and business opportunity benefits, autonomous and driverless vehicles still have many obstacles to overcome before they meet all consumer, industry and legal requirements. These challenges can be grouped into market, technological and legislative categories.

Market and Technology Challenges

Overall, consumer interest in autonomous vehicles is surprisingly high, especially when considering that most consumers never have experienced any form of a self-driving vehicle (see Figure 5):

- A total of 39% of U.S. vehicle owners indicate that they prefer a vehicle with on-demand autonomous capabilities (a button that can be activated and deactivated); 22% prefer a vehicle that can autonomously drive at all speeds and on all types of roads; 17% only prefer a vehicle that autonomously functions in slow traffic and/or on highways.

- A total of 41% of German vehicle owners prefer a vehicle with on-demand autonomous capabilities: 19% prefer a vehicle that drives autonomously at all speeds and on all roads, while 22% prefer a vehicle that autonomously drives in slow traffic or on highways.
However, despite these encouraging numbers, the clear majority of vehicle owners in both countries still prefer to have a nonautonomous vehicle and do the driving themselves. Furthermore, when asked about their main concerns for purchasing an autonomous vehicle, respondents show clear worries centered on technology maturity and cost considerations (see Figure 6):

- 34% of U.S. vehicle owners are concerned about trusting the autonomous vehicle technology; 20% of them are worried about the higher vehicle price for a car with an autonomous driving mode; and 17% are worried about losing control to a computer over how to drive the car.

- For German vehicle owners, this loss of control is the leading concern regarding the purchase of an autonomous vehicle, and is shared by 25% of the respondents; nearly as many respondents — 22% — are worried about the fact that there will be times that the human driver needs to regain control in cases where the technology disengages; 19% of German vehicle owners are concerned about the higher purchase price for an autonomous vehicle.

This underlines the need for automotive, technology and other companies interested in advancing the market adoption for autonomous vehicles to show clear consumer benefits and demonstrate the technology’s maturity and ease of use, including when the system disengages. Additionally, companies must meet consumers’ pricing expectation for autonomous driving capabilities — which today still represents a significant obstacle:

- On average, U.S. vehicle owners interested in self-driving technologies are willing to spend $1,404 dollars for the feature.

- German vehicle owners interested in self-driving vehicles are willing to spend a very similar amount on the technology — an average of €1,061.

- The required hardware cost for today’s autonomous vehicle prototypes totals about $200,000; the typical cost for just the Lidar sensor used in most prototypes today to measure distance by illuminating a target with a laser and analyzing the reflected light represents an $85,000 investment. New advancements in this technology area

![FIGURE 6 Vehicle Owners’ Concerns Regarding the Purchase of an Autonomous Vehicle](image)
such as Velodyne’s Lidar Puck, which costs just $7,999 per unit — albeit with lower performance — are critical to bringing the cost of autonomous vehicles closer to the amount consumers are willing to spend.

Legal Challenges Are the Road Bump for Autonomous Vehicles

One of the biggest hurdles for autonomous vehicles are legal challenges and related ethical questions that can’t be addressed with R&D spending and technology innovations alone. The pressing question is what to do when an autonomous vehicle disengages due to system malfunctioning or even when working properly but entering a driving situation that it isn’t designed to handle (such as entering a street covered with snow during a foggy winter evening)? At a minimum, this will interrupt the user benefit of owning an autonomous vehicle — at worst, this could lead to an accident that might have been prevented if the vehicle was operated by a human driver from the beginning. The complexity of this challenge requires clear directions from lawmakers regarding the definition of responsibilities and liabilities (for the user, owner of the vehicle, and the manufacturer/developer of the vehicle and system). Industry leaders will also need to develop ever more sophisticated technology solutions that introduce redundancy and minimize the chance of system malfunctions and operational limitations. For example:

- Liability issues could be addressed by a no-fault, product-centric reserve that is established and maintained by a joint effort between insurance, automotive and technology companies. Government funds could also be redirected to support such an effort (for example, by making contributions part of a country’s transportation budget).

- The use of remote, human operators (“super drivers”) can address the need for taking over driving tasks via real-time cameras and other sensors to safely steer a vehicle to a safe position when the computer-controlled driving malfunctions.

- Autonomous vehicles should continuously coach human drivers at specific times about how to manually operate the vehicle in order to keep the user’s driving skills up-to-date.

Timeline for Autonomous Vehicle Evolution

Despite the above-mentioned challenges, Gartner believes that the societal benefits from autonomous vehicles will outweigh potential disadvantages and concerns. Furthermore, the potential of fundamental business disruptions from autonomous and driverless vehicles will motivate industry leaders and newcomers to expand research and development activities, and to dramatically advance the progress of the technologies over the next two decades (see Figure 7):

- The evolution of the self-driving vehicle from automated to autonomous vehicles is already underway, and significant investments are being made by individual companies and the entire automotive industry to accelerate the pace of innovation and do actual prototyping on public roads.

- Per Gartner’s prediction from 2012, we continue to predict that by 2016, three companies will have announced concrete plans for upcoming automobile launches that will offer autonomous vehicle technology.

- During 2013, several automakers, including Daimler, Tesla and Nissan announced plans to introduce the first self-driving vehicles in 2020. These early applications of autonomous vehicles will likely be limited regarding their usability based on weather conditions (such as fair weather conditions), road type (such as highway and off-city driving) and performance (such as autonomous driving without passing in the fast lane).

- By 2025, vehicle-to-vehicle and vehicle-to-infrastructure communication will be available in approximately 30% of passenger vehicles in use in mature markets, which will increase the reliability and accelerate the rollout of autonomous vehicles.

- By 2030, autonomous-driving-capable vehicles will represent approximately 25% of the passenger vehicle population in use in mature markets.

The first applications of autonomous vehicles will occur during the next six years, although early examples might be limited to specific road and driving scenarios (for example, only on highways and not in snow conditions).
Evidence
The report references data from a Gartner study conducted via an online survey in 1Q14 to measure consumers’ likeliness to include vehicle-centric information and communication technologies in their next new vehicle. The representative study surveyed 1,086 adults in the U.S. and 1,099 adults in Germany who own or are leasing an automobile.

Note 1
Roots of the Word “Maverick”
Derived from the name of Texas rancher Samuel Maverick and his steadfast refusal to brand his cattle, “maverick” connotes someone who willfully takes an independent — and frequently disruptive or unorthodox — stand against prevailing modes of thought and action.

Note 2
New Ground Broken
This research does not contradict any published positions or forecasts of Gartner, but breaks new ground by considering the impact of Internet business models in a new, more extensive light.

Gartner RAS Core Research Note G00268271, Thilo Koslowski, 03 October 2014

FIGURE 7 Timeline for Autonomous Vehicle Evolution

V2V = vehicle-to-vehicle
Source: Gartner (October 2014)
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