European Commission

Business Innovation Observatory

Internet of Things

Connected cars

Case study 43

Internal Market, Industry, Entrepreneurship and SMEs

Internet of Things

Connected cars

Business Innovation Observatory
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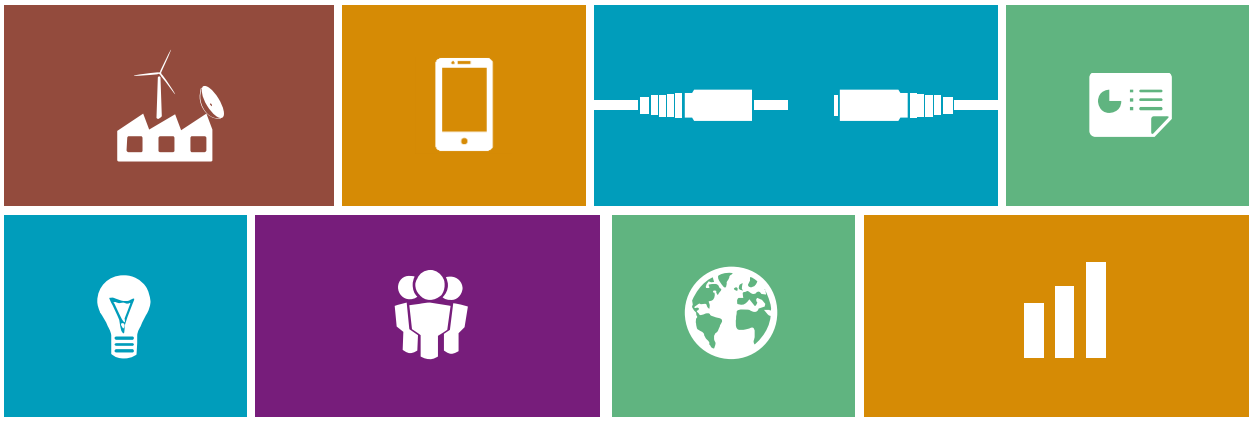


1. Executive summary

In the coming decade, society will experience a radical change in the way mobility is approached. With fast mobile internet access becoming widely available and countless wireless connectivity solutions being adopted on the market, new opportunities emerge for products and services that enable the connected car to come to full fruition.

The connected car is able to digitally connect and interact with its surroundings. This not only includes connectivity with other cars (vehicle-to-vehicle), but also connectivity with infrastructure (vehicle-to-infrastructure) and with other devices (vehicle-to-devices). As such, this ability gives way to a new suite of applications such as advanced safety features, personalised driving and entertainment experiences, and even autonomous driving.

The new opportunities that the connected car provides translate well into its business potential. Although global market size is already estimated to be over EUR 31 billion in 2015, it is predicted to nearly quadruple in size by 2020 to an impressive EUR 115.26 billion in revenue worldwide. Growth will be primarily driven in the market segments of safety features, autonomous driving, and entertainment.

Key stakeholders of the trend primarily include businesses in the telecom, automotive and the ICT industries. With the connected car becoming the standard for new cars in the next 10 years, the automotive industry will drive the demand for chips in the near future.[1]

From a societal perspective, connected cars can help increase safety, productivity, and energy efficiency. Advanced safety features help drivers anticipate dangers and can even prevent collisions. Moreover, with access to information on current traffic conditions on the road, connected cars can dynamically optimise routes, limiting traffic congestions and freeing up time to do other things. The intelligent systems can also help increase fuel economy, e.g. through avoiding traffic jams.

The development and uptake of connected cars solutions in the coming years is driven by an increase in embedded connectivity in cars. In addition, current megatrends on connected devices, energy efficiency, security, and health further drive growth in the segment. Besides this, the uptake can benefit from the realignment of short term milestones with a clear long term vision, from continuous innovation efforts, from the cooperation between different types of actors coming from different industries, and from large-scale investments in infrastructure.

Key barriers faced on the market relate to the absence of or lack of clarity on current regulation and legislation. Furthermore, there are privacy and data security concerns among end-users, who fear that the collected data will give too much insight into their behaviour or that data may be compromised and cause damage, for instance through identity theft or insurance fraud.

Although Europe is well positioned to establish itself as a leader in this trend, policymakers need to bring clarity to the current legislative and regulatory framework. While recent efforts have allowed a degree of autonomous driving, it still requires drivers to take full control over the vehicle if necessary. This effectively prevents initiatives, like the Google car from coming to the European market.

In addition, market uptake can be boosted through pilot demonstrators and investments in public infrastructure. Pilot demonstrators can help show end-users the benefits of connected car solutions. Furthermore, they may bring focus to efforts from stakeholders to invest in the required infrastructure to deploy the technology. Similarly, investments in public infrastructure can drive growth in the vehicle-to-infrastructure applications.

2. Connected Cars

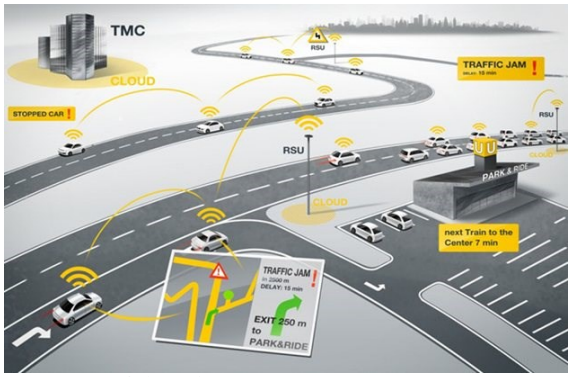
The buzzword in the automotive industry is unmistakably the "connected car". Also leading companies from other sectors, especially the telecom and semiconductor industries, are jumping on the band-wagon that is hailed to be one of the biggest drivers of growth for their business for the coming five years.

To the typical consumer, the connected car appears to be much like the futuristic car - K.I.T.T. - from the 1980s television hit series Knight Rider. This fictional car operated autonomously thanks to Artificial Intelligence and was loaded with computer electronics and sensors that enabled the car to interact with its surroundings.

Nearly 25 years later, the reality is still not quite like K.I.T.T. Nevertheless, the market is rapidly moving towards electronically highly sophisticated and even autonomously operating cars. The connected car in its current state is best described as a platform that enables the exchange of information between the car and its surroundings, either through local wireless networks or via the internet. The interactions made possible by this connectivity can roughly be divided in three categories:[2]

- Vehicle-to-vehicle (v2v) interactions, i.e. cars interacting with other cars;
- Vehicle-to-infrastructure (v2i) or infrastructure-to-vehicle (i2v) interactions, i.e. cars interacting with (roadside) infrastructure and vice versa;
- Vehicle-to-device (v2x) interactions, i.e. wireless communication to any device.

Figure 1: Networked vehicles will interact with their environment, which means communication, data transmission, and shared computational efforts between vehicles, between vehicles and infrastructure, and between vehicles and any other device.



Source: Kapsch (2012)

Regardless of the type of interaction, the key word of this multi-billion business trend is connectivity[3]. Albeit simple in concept, connectivity gives way to applications both for consumers and businesses previously unheard of. The connected car segment is composed of seven distinct product categories[4,5]:

- **Mobility management**. Applications that focus on improving traffic flow and that allow drivers to reach a destination quickly, safely and in a cost-efficient manner. Examples include advanced navigation systems, traffic coordination systems, traffic assistance and parking lot or garage information systems.
- **Vehicle management**. Applications that aid the driver in reducing operating costs and improving ease of use. Examples include dynamic vehicle service reminders, vehicle condition information, remote operation and transfer of usage data for instance for analysis by insurance companies, tax authorities, car rental agencies, or by owners interested in analysing this data on their home computer or portable device.
- **Entertainment**. Applications that are related to entertainment of passengers and drivers. Examples include embedded WLAN hot spots, music/video streaming, social media integration and a smartphone interface.
- **Safety**. Applications that protect driver, passenger and road user safety. These applications can be split up in hard safety applications that aim to avoid imminent crashes and/or minimise damage when they cannot be avoided, and soft safety applications, which respond to safety concerns that do not require immediate reaction. Examples of hard safety applications include blind spot warning systems and forward collision warning systems. Examples of soft safety systems include warning systems for icy roads up ahead, traffic jams, or adverse weather conditions.
- **Autonomous driving**. Functionality involving partially or fully automatic driving. Examples of applications include operational assistance or autopilot in heavy traffic, keep-your-lane systems, automated parking systems and advanced (i.e. adaptive) cruise control systems.

- **Well-being**. Applications that impact a driver's comfort, ability and fitness to drive. Examples include fatigue detection systems and alert calls for medical assistance.

- **Home integration**. An emerging application area that integrates vehicle systems with those at home. This allows drivers or passengers to enable functionality within their house, such as changing the thermostat or turning off the burglar alarm when the car gets close to home.

Although the full potential of the business trend is expected to materialise over the next five years, it should be noted that the technology underlying the connected cars concept is not all new. Connected car services first emerged in the mid-1990s when a number of leading automotive industry players began to employ telematics in their vehicles.[6] Applications which enable connectivity in vehicles that may be considered less revolutionary by today's standards are in fact still part of the trend, with integrated Bluetooth car kits being a prime example.

In addition, more revolutionary connected cars services, such as keyless car sharing applications and cloud connected fleet management, are already commercially available. This case study therefore focuses on the current applications in the connected care market whilst providing an outlook for what is to come in the near future.

The company cases included in this case study have been selected to reflect various market segments of the connected car trend. The European companies have all developed solutions that are already on the market, but are also well positioned to benefit from the market potential we foresee towards 2020. The companies are shortly introduced in Table 1 below.

Table 1: Overview of the company cases referred to in this case study

Company	Location	Business innovation	Signals of success
NXP Semiconductors	NL	NXP's solution brings car-to-x communications, telematics, in-vehicle networking and wireless technologies into the car. The solutions NXP offers work towards improved vehicle access, Near Field Communication (NFC), and multi-standard digital broadcast reception. NXP is also working to deliver advanced technologies such as car radars.	- NXP is driving the technology required for realising the full potential of this business trend. - With EUR 4.16 billion in revenue in 2013, 55+ years of experience in the industry, 8,900 patents and 3,300 employees working on R&D, the company is a leading stakeholder in the semiconductor industry. - Almost all new cars in the world contain NXP chips. - #1 position in Car Infotainment, In Vehicle Networks, and Car Access & Immobilisation.
Keyzee	BE	Keyzee developed a car sharing solution that is fully integrated on a smartphone. This virtual key solution from which the company derived its name provides employees with instant access to the keys to every car in a company's fleet.	- #1 Fleet Innovation Award 2013 for Fleet Suppliers. - Mobility Innovation Award 2014.
Veniam	PT	Veniam developed networking technologies which can turn vehicles into mobile hotspots for Internet access, which can bring car data to the cloud, and which can form a vehicle mesh network that can be used for business, leisure and safety applications, as well as Machine-to-machine data delivery.	- Veniam has built and deployed the largest network of connected vehicles in the world, with more than 600 connected vehicles and 60,000 unique monthly users. - First place at the 3rd Edition of Building Global Innovators.
Cloud Your Car	PL	Cloud Your Car developed a fleet management system that is targeted at small businesses. The application can collect data from vehicles, including start-up, shutdown, location, speed and fuel economy. The data can be used to e.g. minimise operating expenses.	- This Polish start-up company has already offices in San Francisco, Cork and Wroclaw. - 1st prize on the Bitspiration, Krakow (2013). - Secured seed funding worth 300 million USD. - Hailed as one of the 10 Europe-born automotive technology start-ups to watch by tech.eu.

2.1. Presentation of the companies examined in the case study

This section describes four companies that have developed connected cars solutions in response to a clear market need. For each company, the innovation is described as well as the problem it is meant to solve.

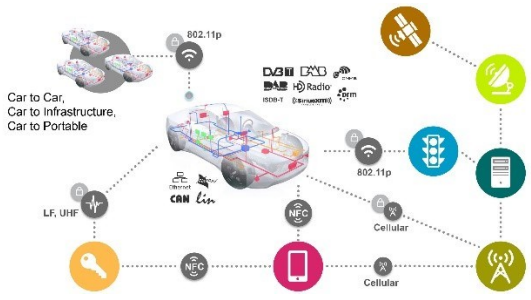
Problem 1 – To function and deliver their potential benefits, connected cars require extensive communication, telematics, and wireless technologies.

Innovative solution 1 – NXP's proprietary technology provides solutions that can readily be adopted by the automotive industry to integrate communication technology in cars.

NXP brings car-to-x communications, telematics, and in-vehicle networking into the car, as well as secure wireless technologies for vehicle access, Near Field Communication and multi-standard digital broadcast reception. NXP is also driving innovation in advanced technologies such as car radar.

Furthermore, NXP is at the forefront of developing integrated hardware and software solutions that tackle cyber-security concerns in the connected car market. Owing to their stake in *Cohda Wireless*, a leading party in the field of security software, the two companies developed the integrated security solution *RoadLINK*™. This solution combines hardware security components developed by NXP with advanced firmware developed by *Cohda*, resulting in a module that protects end-users against illegal hacking and cyber-attacks.

NXP connects the car by providing integrated hardware solutions that enable connectivity and security in and around the car.



Source: NXP

Problem 2 – Sharing a fleet of company cars implies sophisticated management, distribution, and logistics of car keys and registrations. This can be time consuming and it is often not very efficient.

Innovative solution 2 – Keyzee's integrated smartphone solution eliminates the need for a physical car key.

Keyzee developed a car sharing solution that is fully integrated in a smartphone. This virtual key solution, from which the company derived its name, provide employees with instant access to the keys to every car in a company's fleet.

Keyzee estimated that approximately 90% of the time a car is sitting idle. Even on daily commute, this can hardly be considered as resource efficient, especially for companies that need to manage large fleets of vehicles. Traditional car sharing is not efficient enough, as car keys would need to be physically (re-)distributed in order for another user to take that car. As a result, many more cars are taking up space every day than from a macro standpoint would be necessary.

The solution commercialised by *Keyzee* allows users to book and unlock cars through their smartphone.. Moreover, the system provides a real-time insight in the cars that are in use. This allows fleet agents to further optimise their fleet, based on actual use of the cars.

Keyzee is the first integrated car-sharing solution for smartphones that can open, close and start-up cars with your smartphone instead of keys.

Source: Keyzee

Problem 3 – Connected cars require secure, stable, and widespread mobile network and internet connectivity, as they rely for a great deal on cloud computing. Mobile internet is not always as available as required for connected cars to function properly.

Innovative solution 3 – Based on proprietary technology, *Veriam*'s products can transform cars into wireless hotspots.

Veniam developed networking technologies that can turn vehicles into mobile hotspots for Internet access, bring car data to the cloud and form a vehicle mesh network that can be used for business, leisure and safety applications, as well as Machine-to-Machine data delivery.

Veniam's proprietary solution has various advantages over traditional solutions. With their technology, cars can connect to both each other and to communications networks, whether they are cellular or WIFI networks. The result is that their transmission radius is up to ten times higher than with traditional WIFI connectivity. As cars are not solely connected through cellular networks, mobile data traffic is

also greatly reduced. This relieves the network from capacity constraints and has the added benefit for consumers that less mobile data has to be paid for.

Thanks to *Veniam*'s connectivity solutions, more efficient data connections are made possible between cars and their environment. This enables a more cost and resource effective way of sharing data, providing opportunities for e.g. more advanced road-safety and entertainment features in cars.

Veniam developed products that enable vehicular networking in a more cost-effective way with a transmission radius that is up to ten times higher than traditional WIFI connectivity.

Source: http://postscapes.com/internet-of-things-award/2014/connected-transportation

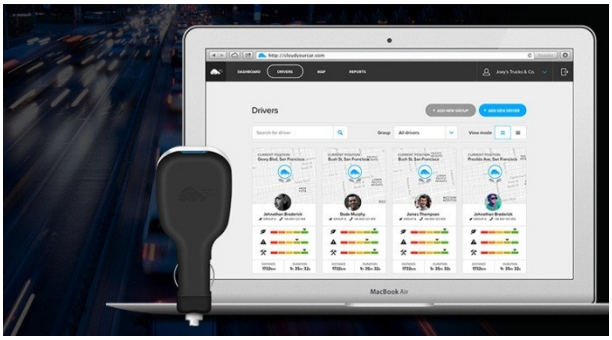
Problem 4 – Further optimisation in fleet management requires fleet agents to have insight in and control over more information from car users in their fleet, e.g. to be able to increase fuel efficiency.

Innovative solution 4 – Cloud Your Car has developed an integrated hardware and software solution that provides fleet agents real-time information from cars in use.

Cloud Your Car is a multi-purpose platform developed to provide real-time insight in a companies' fleet. It consists of a piece of hardware that enables the features in the car (called "Car Beacon") and an easy-to-use cloud-based application. Among other things, the solution can tell you how fast a car is traveling, which routes drivers are taking, and whether the engine is turned on or off. The cloud-based software transforms all of the collected data for various reporting uses, which include driver profiles, live maps, and overall performance overview of the fleet as a whole.

Apart from the innovative features, *Cloud Your Car* is also easily integrated in current fleets and its solutions do not necessarily require embedded connectivity in cars. Moreover, it is a rather cost-efficient solution, costing only 460 PLN (approx. 106 EUR), including a 12-month subscription plan.

Cloud Your Car offers an advanced fleet management solution that can be easily implemented with the help of a device connected through the cigarette lighter. The system sends data real-time to the cloud.



Source: Cloud Your Car

3. Socio-Economic Relevance

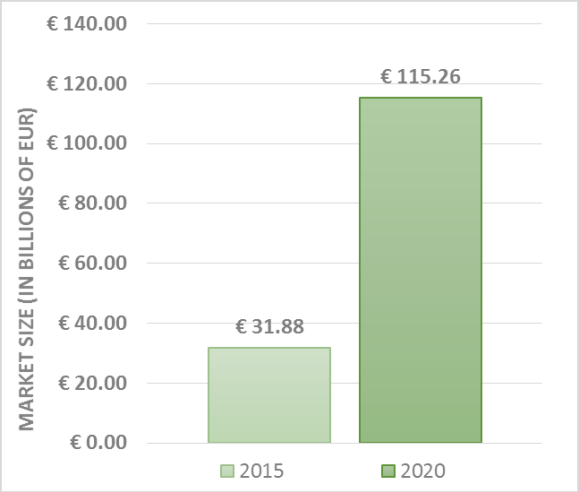
The market for connected cars is booming and it is expected to grow explosively between now and 2020, underlying the staggering growth rates in its various segments. The market potential of the trend is explored in more detail below.

3.1. The market potential of the trend

With wireless technology and high speed internet access rapidly gaining ground, the connected car trend is on the verge of a breakthrough. Indeed, the global market size for connected car components is estimated to equal EUR 31.88 billion in 2015 and it is expected to roughly quadruple in size to EUR 115.26 billion by 2020.[7]

This staggering increase is mostly driven by growth in the application areas of safety and autonomous driving. Particularly safety technologies are expected to remain the biggest market for connected car products as consumers highly value safety features in their cars. Market solutions will most likely include new safety packages from Original Equipment Manufacturers (OEMs) that deploy early warning systems for dangers ahead or even autonomous braking features through the use of sensor technology. This market segment is expected to quadruple from EUR 12.18 billion in 2015 to EUR 47.34 billion in 2020. Demand is expected to be the strongest in the United States, with China and Western Europe to follow behind.[8]

Figure 2: Total market size and potential of the connected car trend (2015-2020), in EUR billions.



Source: Strategy& (2014). Racing ahead – The Connected C@r 2014 study.

In the autonomous-driving market segment, rapid technological advances will drive growth exponentially in the coming five years. New applications, paired with a strong consumer demand will push a five-fold surge in global sales from EUR 7.49 billion in 2015 to EUR 35.66 billion in 2020.[9]

Other segments of the connected car market are also projected to experience significant growth. Entertainment systems are expected to remain popular in the coming five years, with sales in the connected car market more than doubling from EUR 4.93 billion in 2015 to EUR 13.18 billion in 2020. Furthermore, in-car well-being applications are projected to see sales surge threefold from EUR 2.13 billion to EUR 7.13 billion, driven by an ageing society. Moreover, vehicle management systems and mobility management systems are projected to see sales climb from respectively EUR 3.01 billion and EUR 2.12 billion in 2015 to respectively EUR 5.22 billion and EUR 6.67 billion in 2020.[10]

The relatively new application area of home integration is expected to remain the smallest connected car market segment, with global sales increasing from EUR 20 million in 2015 to EUR 60 million in 2020.[11]

The connectivity technology that is expected to be embedded in new cars is also expected to significantly increase. Whereas in 2014 only 5% of all new cars sold worldwide contained embedded connectivity, and 15% of these contained mobile-device tethered connectivity, in 2019 already 57% and 60% of new cars sold are expected to contain embedded and mobile-device tethered connectivity respectively. By 2024, 89% of new cars sold are projected to include both embedded and mobile device tethered connectivity, which translates into 48% of passenger vehicles in the world that will have embedded connectivity by 2024.[12] Although particularly the United States have seen growth in embedded connectivity, Europe is expected to become the largest market for it, with 11.5 million vehicles shipped annually by 2018.[13] This will clearly result in a significantly larger potential user base of connected car applications.

Finally, developments in the connected car market will drive growth in the chip industry. Indeed, demand forecasts show that the automotive industry will be the most important driver of demand for chips, with an average annual growth of 10.4% between 2013 and 2018. The connected car trend evidently also impacts other segments of the economy.[14]

Figure 3: Market size and potential of the connected car trend (2015-2020), per market segment.

Source: Strategy& (2014). Racing ahead – The Connected C@r 2014 study

3.2. The social potential of the trend

Connecting vehicles to the Internet gives rise to many new possibilities and applications, both from a business perspective and from a consumer perspective as well as from a public-safety perspective. For one, connecting cars can make driving safer and reduce traffic congestion, as cars can recognise and anticipate risk and dynamically calculate optimal routes. Connected cars can also drive more energy efficiency by incorporating weather predictions, information on traffic congestions, and specific infrastructural locations in routing and driving behaviour. In addition, connected cars can contribute significantly to road safety by incorporating safety features, such as the European eCall (emergency call) system that automatically alerts the nearest emergency centre in case of an accident.

Increased road safety and reduced traffic congestion can have strong macro-economic benefits that are related to public health expenditure and productivity. With a reduced number of road accidents, also the related public health costs will fall. Moreover, with less time being spent in traffic jams and with car connectivity allowing better solutions for working on-the-go, productivity within society is expected to increase.

The trend also supports job creation. Although estimates for Europe are not yet available, market research shows that in the United States the connected vehicle industry is expected to create a total of 400,000 new jobs.[15] With many initiatives in Europe that relate to connected cars, the trend shows great potential for Europe in terms of job creation in the continent.

The connected car trend will also provide work for the high-skilled labour force, even in the short-term. In the current market, indeed, many technical challenges still need to be addressed, and this requires in particular high-skilled engineers and software developers.

As there are many different industries and actors involved in the trend, it will also bring about substantial indirect effects. The European automotive industry, which provides 13 million jobs in Europe, is considered to be one of the key beneficiaries of the trend. New connected cars standards introduced by the European Commission help to position the European car industry advantageously for the development of the next generation of cars.[16]

Other sectors which are expected to benefit from the market uptake of the trend include the telecom industry, which will take advantage of the explosive growth in mobile data that is expected with the trend.

3.3. A common understanding of the connected cars value chain still needs to be developed

The connected car value chain is part of the value chain of the Internet of Things[17], considered as extremely complex in the literature[18]. It is also linked with that of the automotive sector, which in turn is also of rather complex nature. Moreover, the ecosystem of connected cars is growing rapidly, making it more difficult to fully establish the value chain.[19] It is thus hardly surprising that the connected car value chain is still not widely understood, which has resulted in a call for action in the recent literature to develop a shared understanding of it.[20]

What can be certainly said about the value chain for connected cars, however, is that a number of key actors and industries are interlinked. These predominantly consist of companies in the automotive, telecom and ICT industries. The automotive sector is for obvious reasons involved in integrating solutions for connected cars in their new vehicles. The telecom providers enable high speed and high bandwidth mobile connectivity, inside and outside the car. ICT companies can be further disaggregated to companies that provide software (i.e. "apps") that enable connected car features, and companies that develop and manufacture the hardware (e.g. chips).

On top of the industry partners involved, it needs to be understood that actors from the academic and public sector are also largely concerned. Moreover, service industries, such as consultancy or marketing fields, are increasingly more involved in the industry. In addition, effects are likely to trickle down to the construction industry, as infrastructure will need to be updated over time to allow for v2i-interactions.

Also taking the perspective of customers (i.e. end-users), the value chain is not easily described. Being it spread out over so many actors and industries, end-users can range from automotive manufacturers to semiconductor companies, app designers and even consumers.

The complexity of the value chain is also made evident by the companies in this case study. *NXP Semiconductors*, for instance, supplies the automotive industry with chips for embedded communication technology. The automotive industry itself sells these cars, through dealerships, to consumers. Together with the chips supplied by NXP, automotive companies also provide a platform for app-designers to create applications for connected cars (e.g. *Keyzee*, Cloud Your Car). Using these applications is made possible with the help of broadband mobile data services, which are provided by telecom operators. However, the data services provided by telecom companies allow the trend to take off in the first place, which showcases the numerous interlinkages between the various industry partners in the value chain

4. Drivers and obstacles

The development and uptake of connected cars solutions may benefit from current megatrends, from realignment of short term milestones with a clear long term vision, from continuous innovation efforts aimed at staying in the 'driving seat' when the full potential of the trend unfolds, from cooperation between different types of actors from different industries, from embedded (wireless) communication technology, and from large-scale investments in infrastructure. Regulation and legislation are both a driver and an obstacle for success. Embedded (wireless) communication technology is a key driver, but its absence limits the market for connected cars. These drivers and obstacles are discussed in more detail below.

4.1. Megatrends are driving growth for connected cars

The market for connected cars is driven by megatrends that apply not only to this specific market segment, but to the economy as a whole. NXP identified the following four megatrends that are particularly significant in driving growth for connected cars:

- **Energy efficiency.** One of the key societal benefits of the connected car is its potential to bring fuel economy to a new, higher level. Applications already on the market, such as Cloud Your Car's advanced Fleet Management Solution, give more insight into the fuel consumption of drivers. This allows the user to better manage the fuel economy of the fleet by e.g. setting targets or providing bonuses for a high level of fuel economy. Moreover, both assisted and autonomous driving can further drive down fuel consumption through (nearly) perfect driving. In addition to this, advanced traffic control systems made possible with connected car technology will reduce traffic jams and subsequently fuel consumption.**Connected devices.** A surging growth in the number of internet and smartphone users has already provided a customer base, which

will continue to increase in size in the coming years. Likewise, not only is the adoption of wireless communication technology a growth driver, so is the adoption of related devices and solutions, such as smartphones, speech recognition software, and third-party apps. The increasing integration between devices and between applications will fuel growth in the connected cars market by allowing companies to take advantage of new application possibilities and of a much larger end-user base.

- **Security.** Although a lack of security greatly impedes market uptake, the bigger trend of a demand for security features provides growth potential for connected cars solutions. Advanced security features, such as real-time tracking of a car in case it is stolen, will become increasingly more in demand over the next few years.

- **Health.** Strongly related to an aspect of safety, the megatrend for health drives a demand for safety features all across the board. Connected cars integrate successfully into this trend as they are able to provide drivers with unprecedented safety features on the road. On top of that, connected car applications in the near future may be able to provide personalised health features, such as the identification of personal health conditions while on the road and anti-fatigue systems.

Apart from the four megatrends identified by NXP, other overarching trends drive growth for the connected car market. These trends include:[21]

- **Pervasive access.** Customers are more and more willing to trade personal information for free content, and they expect a seamless on-the-go experience – both of which the connected car can provide.

- **Safety.** Connected car technology allows for much more sophisticated safety features, such as early warning systems, blind spot detection and automated or assisted braking. The integration of such advanced safety features in new vehicles is predicted to rise from 10.2% in 2012 to 49% in 2017.

- **Personalised experience.** In today's society, increasing emphasis is put on personalisation, customisation and user-friendliness. The connected car can adapt to the driver by bringing personalised dashboards, information, media and, in the future, advertorials.

- **Younger generation.** Considered as one of the key external growth drivers, the younger generation of drivers puts more emphasis on social media, connectivity, productivity, practicality and fun while being in a car. Connected cars can provide this integration seamlessly.

4.2. Realigning short term milestones with a clear long term vision increases the chance of success

Although the connected car trend already creates opportunities for companies in various industries, its market potential shows that many more opportunities are yet to come. In order for companies to capitalise on the trend, it is of high importance that they have a clear long-term vision while setting and (re-)adjusting short-term goals along the way.

Many of the companies that are currently successful in this trend can be considered early-movers. In a market where technology has not fully matured yet and where the uptake is still relatively small compared to its potential, business models often need to be re-invented along the way. Hence, it takes a clear long-term vision with realistic short term goals aligned with it to be successful as the market is still rapidly changing.

However, aligning the short-term goals with their long-term vision sometimes requires companies to rethink their business strategy.

"We had a big vision and long term plans, but we planned it all step by step. We verify, go over every element again and again, write more hypotheses."
– Cloud Your Car

A good example in our case study sample can be found in *Cloud Your Car*. The founders of the company thoroughly analysed the market for Fleet Management Solutions, carefully considering what their potential client base would want out of a new Fleet Management Solution. It became apparent that a new solution needed to be developed, which would take months.

To ensure that they would stay on the right track, they carefully planned every step along the way. A strong vision for the long-term was paired with milestones on the short-term, which turned out to be key to achieving their success. While executing their business plan, the founders would continuously go over every element again and again, and re-adjust if necessary. This has allowed the company to be flexible enough in a rapidly developing market while staying on-track towards their long-term goal.

4.3. Continuous innovation is needed to stay in the 'driving seat' when the full potential of the trend unfolds

Technology is driving the trend of connected cars. In the coming years, the market adoption of vastly improved new technology will help unlock the full potential of the business trend. With this, new or more sophisticated solutions will be made possible, meaning that companies will need to keep innovating along the way to stay on top of their market.

If companies fail to improve on their products over the next five years, it is likely that (new) competitors will gain significant market share with products that are based on newer technology. This newer technology will allow for new features to be incorporated, making current solutions in many cases outdated or even obsolete.

Companies that keep innovating are well positioned to reap the benefits of their efforts in the near future. With developments in e.g. v2x-communications, integrated solutions between household devices and cars will bring new opportunities across the board. By rapidly taking advantage of these new developments, companies like *Keyzee* and *Cloud Your Car* have demonstrated this already, while others such as *NXP* and *Veniam* show that by developing such solutions companies ensure that they stay ahead of their competitors

4.4. Cooperation between different types of actors from different industries drives success

The complexity of the connected car value chain demonstrates the notion that many different types of actors from different industries are involved in this business trend. Unsurprisingly, the cooperation between such different actors is a strong pre-requisite for companies to unlock the full potential of this trend.

With different market segments and niches involved, it is unlikely that a single party is able to drive and control the complete value chain. Just to name a few examples, semiconductor companies are needed to develop and manufacture the necessary technology for e.g. connectivity, automotive companies are needed to develop and manufacture the vehicles, telecom operators are needed to provide the mobile network infrastructure and software developers are needed to create content for the connected car.

"Connection to universities and research groups is key to success" **– *Veniam***

In order to successfully bring connected car applications to the market, a tendency to partner can be observed across the entire trend. *NXP* works closely together with both the telecom industry and the automotive industry. The automotive industry in turn partners with software developers to create content for their integrated car solutions. *Veniam* also showcases the tendency to team-up with other organisations, in particular with eleven partners that range from leading universities and institutions to public agencies. Moreover, *Veniam* successfully tested their technology on more than 450 taxis from the fleet of *RadiTaxis* in the city of Porto.[22]

Keyzee also provides an example of how cooperation between different actors can result in an innovative solution. As they were testing out innovative ways of car sharing, they recognised that they needed external expertise to further solve some of the technical constraints of their solution. Specifically, an early prototype required cars to be always connected to a network to receive bookings via GPRS. However, in cities most cars are parked underground, where no GPRS coverage is available. In cooperation with another company, *Productize*, they were able to overcome this problem by re-designing and further refining their technical solution. This ultimately resulted in the *Keyzee* box that is available on the market.[23]

4.5. Regulation and legislation is both a driver and an obstacle for success

Regulation can be both a serious barrier and a driver for the uptake of innovative technologies. This is no different for the connected car business trend..

On the one hand, regulation in Europe is helping to pave the way for more innovative solutions. For instance, Europe's eCall system, an integrated telecommunication solution helping in case of serious accidents, will be mandatory for new cars from October 2015. In case a serious accident with a vehicle occurs, the system will automatically transmit an alert to the nearest emergency centre. Market research has suggested that the eCall regulations will significantly drive growth y in this sector between 2015 and 2020.[24]

On the other hand, a lack of clear regulation and legislation is without a doubt a barrier to growth, especially with respect to liability and to the applicability of telecom laws to providers of electronic communication devices. With the technology for assisted or autonomous driving developing rapidly, uncertainty on liability is a growing concern.

If connected cars may ever cause a road accident, the key question is who should be held accountable. If it is a software malfunction, it needs to be clear whether the app developer should be held accountable. The same applies to a hardware component supplier in case of hardware failure, or to the car manufacturer to which the hardware component was provided. Without clarity, insurance companies will not know where they can rightfully claim the damages and companies will not be able to assess their liability.

Even if liability can be established, current legislation can still become troublesome. For instance, even if telecom companies were to be held liable for accidents caused by network interruptions, German law states that they can be held liable for a maximum of EUR 12,500 of damages per damaged party. Drivers or insurance companies may end up with high bills to pay in case they are considered liable for accidents where a connected car is involved.[25]

Moreover, integrated communication solutions raise questions on whether the automotive and semiconductor companies delivering these solutions need to comply with telecom laws.[26] This could mean that e.g. car manufacturers and OEMs will require licensing or general authorisation from telecom authorities. As especially these companies operate in multiple countries, they could in theory be subject to all sorts of telecom regulation. If this is indeed the case, then current legislation may seriously impede growth in this segment over time.[27]

4.6. Privacy and data security are a key concern among customers which dampens market adoption

With increasing connectivity and digitalisation comes another key challenge: data security. The more unsafe connecting a car is perceived to be, the fewer end-users will want to use it, effectively preventing a strong market uptake.

Connected cars are potentially very vulnerable to **cybercrime**. In fact, researchers have already shown that malicious input can be delivered through compromised MP3s, infecting a whole network of cars in a near instant.[28] This can cause both financial damages and safety hazards to the users of connected cars, e.g. by turning off vital functionalities of the car that jeopardise the safety of drivers or by compromising credit card information stored by connected car services.

Privacy is another challenge that needs to be tackled in the near future to ensure a strong market uptake. With cars collecting data on almost every step along the way, it is theoretically possible to have complete insight into what a driver has been doing. While some applications use this feature of connected cars to provide new services, such as *Cloud Your Car*'s fleet management solution, it may backfire if consumers feel that their privacy is in jeopardy. In fact, a recent study shows that 51% of new-car buyers in Germany are reluctant to use car-related connected services because they want to protect their privacy.[29] Therefore, in order to establish a large end-user market, solutions need to be developed that maintain privacy of end-users.

"NXP's follow-on investment in Cohda Wireless represents another significant step in our quest to make the secure connected car a reality." – ***NXP***

That is why companies on the market are working hard to try and resolve the issues of **cyber-security** and **privacy**. In order to take on the challenge, *NXP* recently announced a follow-on investment in *Cohda Wireless*, a leading software specialist for automotive safety applications.[30] In 2013 they acquired a stake in the company – together with Cisco – to jointly develop an integrated security solution, named *RoadLINK™*, which integrates NXP's hardware security modules with *Cohda Wireless's* advanced firmware. The module protects consumers and industry against illegal hacking and cyber-attacks and can be integrated in cars.

With respect to the privacy concerns, *Cloud Your Car* deliberately opted for a visible solution in the car. The presence of the required dongle clearly signals to the user that some information is collected and adds to a sense of transparency about this. An extra benefit of the dongle is that it does not tap into the car's systems, minimising the safety risks of cybercrime on users.

4.7. Embedded (wireless) communication technology is a key driver, but its absence limits the market for connected cars

Market uptake in this trend is clearly driven by the development and adoption of wireless communication technology. On the one hand we observe an increase in embedded communication technology in cars, which allows companies on the market to develop new integrated solutions that communicate with a car. On the other hand, the substantial improvements in high speed mobile internet access allow data to be shared in a much larger ecosystem. This gives way to numerous new applications and business opportunities, ranging from advanced safety and early warning features up to real-time remote fleet management.

However, embedding wireless technology in cars is a rather recent trend. While exponential growth is expected in the number of new cars with embedded connectivity, it will take up till 2024 before approximately 48% of passenger vehicles globally on the road will feature it.[31] The good news is that the end-user base will increase in size exponentially in the coming decade, providing more and more business potential. Nevertheless, growth is currently limited to the relatively small market penetration of embedded connectivity in cars.

Moreover, stakeholders of the trend need to find a way to both transmit and analyse the enormous amount of data that will follow from connecting cars. Wireless connectivity will surely improve in the near future, with more wireless hotspots becoming available and mobile network operators expanding capacity and increasing bandwidth of their networks. However, the vast amount of data that will potentially be transmitted may be very costly given the current rates for mobile data.

In response to the challenge, *Veniam* developed a technology that transforms cars in wireless hotspots. By connecting cars through a chain of wireless hotspots, data may be shared at higher speeds and lower costs.

Solutions may also be developed that aggregate data points and transmit the required data from wireless hotspots to cloud connected services through local infrastructure, such as internet access points. This could both push down the costs of the data and increase the computing power through cloud computing.

4.8. Market adoption of more advanced connected car applications requires large-scale investments in infrastructure

While the market is advancing relatively well on v2v (vehicle-to-vehicle) and v2x (vehicle-to-device) solutions, v2i (vehicle-to-infrastructure) solutions require significant upgrades to infrastructure before companies can tap into their potential.

Connectivity with infrastructure allows numerous new applications for the connected car market. These applications range from advanced safety and traffic control features up to localised weather warning systems, stop sign violation warning systems or electronic road-toll systems, such as Toll Collect in Germany and Liber-T in France.[32]

From a technology perspective, companies like *NXP* and *Veniam* are developing cutting-edge solutions to enable connectivity in cars. NXP is at the forefront of the development of all sorts of connectivity solutions, such as car-to-x communications, telematics, in-vehicle networking, and Near Field Communication. With *Veniam*'s technology, vehicles can be turned into WIFI hotspots, enabling further connectivity.

However, for interaction with infrastructure, both companies are dependent on the ability of infrastructure to communicate with the (integrated) solutions in the cars. Moreover, other companies that could e.g. develop software or content that is based on v2i solutions also require that the infrastructure is able to provide them a platform for this. The automotive industry is even reported to be reluctant to add such new features to cars as long as the necessary infrastructure is not being built by public authorities.[33] The absence of investments in advanced infrastructure therefore impedes further growth in this segment.

5. Policy recommendations

Although Europe is well positioned to take a leading role in this trend, policymakers need to address concerns on current legislation and regulation, and concerns related to privacy. In addition, market uptake can be boosted with the help of pilot demonstrators and investments in public infrastructure. The policy recommendations are discussed in more detail in this section.

5.1. Legislation and regulation require further attention from policymakers

One of the key barriers that companies are facing – and will be facing in the coming years – is the absence of or the lack of clarity on legislation and regulation that applies to the connected car market. One the one hand legislation needs to be implemented that legalises road use of autonomous vehicles, whilst on the other hand clarity needs to be provided on which regulations apply to companies in the connected car industry.

Until recently, a significant hurdle that needed to be taken was amending the UN Convention on Road Traffic, which stipulated that a human driver must be in control of a vehicle at all times. In April 2014, however, the convention was amended to read that a driver needs to be able to take control of the car at all times, instead of operating it at all times.[34]

Although representing a significant step forward, this also implies that fully autonomous cars that do not contain a steering wheel, such as the Google car currently under development, are not allowed on the road in Europe. Paired with the requirements for driver competence in case a vehicle needs to be controlled (i.e. drivers licences), this potentially impairs the market uptake of connected cars. Also, the absence of EU-wide rules for self-driving functionality will complicate the introduction of semi-autonomous (level 3) and fully autonomous (level 4) vehicles in Europe.[35]

Despite these concerns, Europe is well positioned to establish itself as a leader in this trend. Various countries (e.g. Sweden, The Netherlands, the UK, Germany, Spain) already allow road tests and many are in the process of developing legislation that will allow road use of (nearly) autonomous vehicles. By quickly developing a harmonised European legal framework that addresses concerns on liability and self-driving functionality, especially for semi-autonomous and fully autonomous vehicles, Europe can gain a competitive

edge over other regions where such a framework is not yet in place (e.g. the US).

5.2. Pilot demonstrations can boost market uptake of the trend

With the connected car, the market for vehicles will shift to a whole new paradigm. As discussed in this case study, the connected car will show digital interaction with other vehicles, with infrastructure, and with devices in a manner unlike anything consumers have seen before. This requires the necessary functionality and infrastructure to be available as well as awareness among end-users of the capabilities of connected cars.

Pilot demonstrations are an effective policy tool to address these points. By setting up pilot locations that demonstrate the capabilities of connected cars, end-users can experience for themselves what advantages the new technology brings to them. Pilot demonstrations can also stimulate different stakeholders to dedicate the necessary investments in a coordinated way, as the projects are typically of small scale and have a clear focus.

There are already a number of good initiatives under way in Europe that could be further explored. One example is the European Innovation Partnership on Smart Cities and Communities (EIP-SCC).[36] The EIP-SCC is an open platform that aims to improve urban life through more sustainable integrated solutions, which includes better transport solutions. Although the EIP-SCC is not a funding instrument, commitment could be sought among members to develop pilot demonstrations on specific locations that e.g. integrate infrastructure and vehicle communications in an innovative way.

In addition to the commitments established through the EIP-SCC, Calls for Proposals within Horizon2020, the EU Framework Programme for Research and Innovation[37], should facilitate the further development and deployment of connected car technology. With respect to pilot demonstrations, Calls for Proposals could be drafted that focus on connected car technology.

5.3. Investments in infrastructure are needed to bring v2i applications to the market and enable autonomous driving

In order to take advantage of the trend and position Europe as a leader in the market, investments in infrastructure are required. These investments are particularly needed to allow for vehicle-to-infrastructure (v2i) communication, which in turn allows for the deployment of radical new features such as cars responding to road signs, traffic lights and car parks.

A key challenge with respect to infrastructure is that these investments are unlikely to come from industry. As the majority of the public infrastructure is not under the responsibility of industrial actors, public authorities need to step up in order to encourage the connected car to reach its full potential. It is essential for some of the more advanced upcoming features that cars are able to communicate with the infrastructure. Public actors can accelerate the process by investing in connected infrastructure features, such as integrating red light violation warning systems at busy intersections and curve speed warning systems at dangerous roads.

The recently announced Investment Plan for Europe, a joint initiative from the European Commission and the European Investment Bank, could enable some of these investments. A Task Force has been set up to look into potential barriers and to screen potential projects that will be financed within the EUR 21 billion initiative.[38] Specific attention could be devoted to a number of projects that will bring the infrastructure for connected cars to a new level.

Furthermore, through the Horizon2020 framework, financial support may be provided for pilot demonstrations that specifically focus on the development and deployment of v2i applications. This will both showcase the possibilities to end-users as well as set an example for other regions to dedicate investments in infrastructure that enable v2i-communication.

5.4. Privacy concerns of end-users require attention from both industry and policymakers

Maintaining privacy is of key importance for the market to take off exponentially in the coming years. Although part of the responsibility to come up with a solution lies with industry, public authorities can play a role in addressing privacy concerns.

One way to address privacy concerns is to further explore a need for harmonised European regulatory action. By setting clear regulation on minimum requirements for privacy provisions in connected cars (or connected devices as a whole), the market would be forced to come up with solutions that are to the benefit of the end-users. As a starting point it could be considered whether the current ePrivacy Directive (Directive 2002/58/EC) is sufficient for ensuring the privacy of end-users of connected cars.

Nevertheless, even if current regulation is considered sufficient, the perception of end-users would still need to be addressed. Policy makers at all levels should seek discussions with industry to exchange views on how to best address the privacy concerns of end users, and organise initiatives to take away as much of the public concern as possible, e.g. through campaigns, workshops or public demonstrations.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
NXP Semiconductors	Mark Hamersma	General Manager and SVP Emerging Businesses
Keyzee	Thibaut Cardinael	General Manager
Veniam	João Barros	Founder
Cloud Your Car	Patrick Szymczak	CEO

6.2. Websites

NXP Semiconductors	www.nxp.com
Keyzee	www.keyzee.eu
Veniam	www.veniam.com
Cloud Your Car	www.cloudyourcar.com

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