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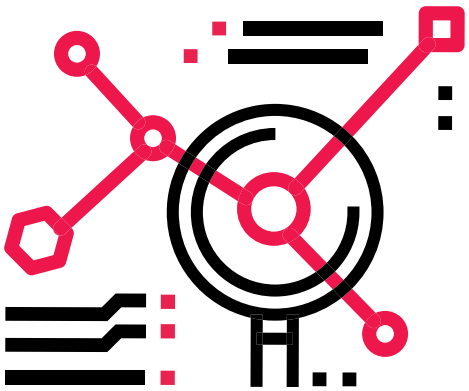

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# How will 5G revolutionise the European automotive industry?

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# Summary

5G is more than just the next step in wireless. It is the foundation for developing more efficient industry and smarter technology as well as innovative ways of communicating with the world around us.

The impact of 5G technology on the entire automotive ecosystem will be tremendous. It is sure to send shockwaves through the industry and cause fundamental changes - not only in the core product it manufactures, the car itself, but also in the business models of suppliers who deliver all complimentary products (including semiconductors) as well as usage models. Europe will not be spared this disruption.

This paper discusses 3 aspects of the European mobility ecosystem that, more than others, will be impacted by the full launch of 5G technology:

- 5G will enable enhanced V2X communications for connected cars and automated driving
- Mobility as a Service (MaaS) will revolutionize the passenger experience
- Cooperation between players from the automotive and ICT industry is sure to evolve as a result of 5G

It is, however, important to note that ensuring that positive impact of 5G on the European automotive industry requires addressing some key policy areas. The recommendations made by the author in this regard have been divided into three respective categories: those relevant to EU bodies, those regarding ideas to be potentially implemented at the national level and those to be considered by OEMs and ICT industry players.

# Contents

# Introduction

According to recent studies by Qualcomm and IHS Markit[1], by 2035, 5G will generate more than $2.4TN in total economic output across the automotive industry, its supply chain, and its customers while creating 22 million jobs. It is in fact predicted that the automotive industry will be a key recipient of the benefits of 5G. The capabilities of exciting mobile connection technology are often insufficient to meet the current needsof businesses as well as individual customers and both of these groups are eagerly awaiting the roll-out of 5G which is expected sometime around 2020. Although the infrastructure is still being put into place, it is almost certain that when 5G finally becomes available, it will regularly deliver transfer speeds of hundreds of megabytes per second, in contrast to the low tens of megabytes that even good 4G connections usually struggle to reach at present. One of the minimal requirements of 5G is that each cell must be able to handle at least 20 billion bits of downloaded data per second. That is 20 times more than today's best Long-Term Evolution (LTE) cells. Next-generation cells are also supposed to support one million connected devices per square kilometre.

In addition to faster transfer speeds 5G will deliver increased reliability and lower latency hence creating a wide range of new possibilities. According to Soldani (2014), 5G will in fact significantly contribute to the development of the portion of the Digital Economy which is centred around robots working alongside humans what will free people from performing many cognitive, outdated tasks and create new job opportunities. IHS Markit analysts go even further and refer to 5G development a part of an elite class of socio-economic drivers known as General Purpose Technologies (GPTs). Widely adopted across multiple industries, GPTs are often catalysts of transformative changes that 'rewrite the rules of competitive economic advantage'. They are widely used in all sectors of the economy and make complementary innovations available to people from around the world. In the case of 5G, it is particularly smart devices that are expected to see a major boost in their interdisciplinary utility and capability, with the most-cited example being the wide-scale deployment of truly connected and automated vehicles (CAVs).

Although there are many analyses of the impact of 5G technology on the American automotive market, there is no single comprehensive study with regard to this issue, covering not only the new technologies being launched, but also the applicable regulatory ecosystem in Europe. The '5G Automotive Vision' White Paper, which was co-published by ERTICO Europe, the European Commission (EC) and the 5G Infrastructure Public Private Partnership (5G PPP) in 2015, is already partially outdated as a result of significant advances in 5G. The rest of the reports, which are at least somehow related to the topic, focus either on the connection between the deployment of 5G and fully autonomous cars or predictions regarding sales figures resulting from such an advanced technology while completely neglecting the disruption in bound to take place in other sectors of the industry. Therefore, the purpose of this report is to provide the information necessary to analyse changes that will occur in the European automotive industry once 5G is given a chance and find potential ways in which the technology can positively impact the industry. For this purpose, extensive data collection from secondary sources has been supplemented by substantial industry-wide research covering the viewpoints of new entrants, start-ups, academics as well as main affected players including Original Equipment Manufacturers (OEMs) and Information and Communications Technology (ICT) companies.

For the purposes of this study the author has defined the 'automotive industry' broadly - to include not only the manufacturing and sales of automobiles but also new business models and changes taking place in the transportation and logistics sector. As it is still too early to provide a concise report on the effects of 5G on all of the different players within the automotive industry, this study proved examples of how the communicational functionalities offered or facilitated by 5G will have a meaningful impact on other technologies thus leading to horizontal changes within the industry itself - influencing both businesses and consumers.

Since the focus of this study is specifically on 5G and not any other technological advancements that might revolutionise the automotive industry in years to come (especially robotics, machine learning and artificial intelligence), the key issue addressed here has to do with the impact that the evolving communication capabilities of cars will have on the business models of manufacturers and services providers within the automotive industry. While there may be a significant degree of interaction between 5G and these other technological developments, the author of this report has been careful to distinguish between the benefits of more autonomous vehicles as such, and the specific benefits offered by 5G and its role in fostering better connectedness, greater autonomy and new business models within the industry.

[1] Campbell K. et all (2017), *The 5G economy: How 5G technology will contribute to the global economy*, IHS Economics & IHS Technology.

The technical aspects of features of automobiles that will benefit from 5G technologies such as radio interfaces, spectrum or service architecture design are mentioned only where indispensable. This is intentional as, in an effort to find optimal solutions, numerous features are still being tested. In addition, there is a vast amount of literature on the general technicalities related to 5G which, in many cases, would be relevant to our study. As a result, the estimates and predictions presented here are based on experience, official expert opinions and, where possible, simulated results. They are intended to give the reader a point of reference as to scale rather than an exact value.

Content-wise, some regulatory solutions associated with 5G in the automotive industry, mostly those related to autonomous cars, from the United States as well as selected Asian countries, are presented here to provide an enhanced comparison. A section on current European regulations will follow.

Building on this background, 3 case studies will be presented. These cases were selected based on specific criteria: the magnitude of the impact that 5G technology will have on each one and the fact that each of them provides a detailed illustration of the changes and challenges faced by key links in the transformed automotive industry – including OEMs, passengers as well as network providers. These case studies and policies they contain are also a top priority from the EC perspective.

Despite the limitations related to the physical size of this report, the author decided to examine these 3 holistic case studies separately to better illustrate the disruption that can take place from various perspectives. This approach was also chosen to improve the readability of the study. In order to avoid repetition, the description of each individual case study is preceded by a short regulatory background, while the 'conclusions and recommendations' section consists mainly of analytical materials used to synthesize the information that has been gathered as well as present key learning in terms of steps that can be undertaken to enhance positive impact of 5G on the automotive industry in Europe. This last section of the report is also used to underline certain focal points regarding bottlenecks and capacity constraints.

Last but not least, it must be emphasized that the focus of this study is on the broad European perspective. The core of this research is therefore focused on EU bodies rather than specific Member States (MSs) and their internal policies. Nevertheless, in an effort to show that European initiatives aimed at introducing 5G in a timely matter can be additionally reinforced on a MSs level, some specific recommendations for EU capitals will be provided. It is important to take note of the fact that the gravity of the initiatives of individual MSs, may increase the benefits, especially if concise pan-European regulations are not put into place shortly.

# The global regulatory challenge: 5G and the automotive sector

Over the last decade, the global automotive industry has undergone the greatest transformation it has experienced in its history. The automotive revenue pool will grow and diversify with new services - potentially becoming a $1.5TN market in 2030 according to McKinsey & Company (2016). However, the discussion on new technologies such as autonomous driving is characterized by highly fragmented regulatory approaches in key markets – the US, EU and Asia – leaving the international industry uncertain and slowing.

Autonomous cars, seen as the ultimate goal of 5G functionality, rely on a wealth of cameras, sensors and radars to identify information about the surrounding environment. This will require to up to 4000 GB of data per car per day. And that data needs to be transferred,interpreted and implemented in a split second to keep cars and their passengers safe on the road. Trials of 5G networks that can handle these massive amounts of data are already underway and they are expected to become available by 2020. But what about security and privacy issues? On an international level, it has been developments in Cooperative Intelligent Transport Systems (C-ITS) that has been the catalyst in considering the regulatory implications of these systems. There has been significant progress in several regions, most notably in Europe, but also Japan and the US. International organizations that deal with spectrum harmonization efforts, such as the ITU, Europe CEPT and Asia Pacific Telecommunity, have also started addressing ITS systems as a whole and, more specifically, C-ITS systems in the 5.9 GHz band.

This snapshot offers insights into the current situation and expected developments in the three key epicentres – current policies, priorities as well potential barriers and opportunities – all while taking under consideration the most common legal challenges.

# 5G (autonomous) Americas

5G Americas is an industry trade organization composed of leading telecommunications service providers and manufacturers advocating for and fostering the advancement of LTE wireless technologies and their evolution into 5G, throughout the ecosystem's networks, services, applications and connected devices in the Americas, particularly in the automotive industry. Not surprisingly, with the growing embedded and smartphone telematics, the US auto industry is transforming rapidly and leaving the association with a growing amount of work.

Despite the global economic turndown in 2009 and flattening sales in 2015-2016, the automotive industry remains one of the nation's most significant in terms of not only jobs (roughly 8 million in direct and indirect employment) and GDP percentage (historically 3-3.5%) but also in terms of research and development (R&D) – with upwards of $300B spent since 2014 and, of course, capital investment – with over $200B annually as calculated by analysts from FTI (2017).

At the same time, few beyond that industry would argue that the momentum behind one of the biggest shifts this sector has ever faced – Connected and Automated Driving (CAD) – comes largely from outside the biggest auto OEMs. Tech-giants like Google and Uber, regardless of their scale, short history or expertise in mobility, have done more in the past decade to make autonomous vehicles (AVs) a tangible possibility than traditional car manufacturers.

Among many other factors, this disruption in vehicle innovation has put in motion a uniquely American pattern of simultaneously intense competition and surprisingly flexible collaboration – with companies flocking to Google and Tesla to learn about electric vehicles (EV) and AV technology and old-line players, like GM, investing in start-ups like Lyft. On a different note, there is Intel's acquisition of Mobileye which has much broader implication than just in the realm of Mobileye's core business of sensors and machine vision – and Intel is making no secret of that. The resulting tension within the industry has also created a unique environment in which regulations and policies tend to lag behind the reality faced by consumers as well as the industry even more so than usual – this despite considerable efforts on the part of both traditional and non-traditional players in mobility.

With tens of thousands of nearly autonomous vehicles on US roads right now, to date, the country has been incapable, at the federal level, of creating or implementing a usable framework for testing and assessing AV driving – leaving states to decide for themselves how best to address the rapidly growing pool of AV enabled cars. While Nevada decided to make self-driving long-haul trucks legal, some other states are still paralysed and are waiting for a federal game-changer.

Nevertheless, keeping in mind the top priority that safer roads and improved mobility are for every government, federal and state authorities are interested in supporting the technology with various incentives and try to not be a roadblock for attractive, long-term visions. As a result, cyber security has finally gotten some well-deserved attention and even OEMs are currently scrambling to catch up and get involved in putting together laws & regulations that will address the uncertainty of the current status-quo.

Given all of the above, we can likely expect to see individual states and companies experimenting even more decisively with smaller-scale developments related to 5G and an autonomous driving ecosystem in the near future. We should also assume more dramatic discussions on safety with examples such as the well-publicized incident of a Tesla driver who died because he relied too heavily on the car's autonomous systems to protect him from road conditions which, as it turns out, are still not entirely possible to predict.

Interestingly, on the federal regulatory front, the recent framework created by the Federal Aviation Administration (FAA) for commercial and consumer drone use offers some cause for optimism. Essentially starting from scratch in 2014-2015 the FAA arguably created a regulatory and policy mechanism, along with enforcement guidelines, that by 2017 has encompassed literally hundreds of companies and thousands of use cases for an emerging technology with similarly explosive, if not yet realised benefits across industries. Meanwhile automation technology will continue to be an ever more present part of everyday lives. It is therefore quite likely that, within the next couple of years, the US will become the 'birthplace' of a major, countrywide policy related to the use of 5G in the automotive industry.

# Almost all Asian roads lead to 5G

Although North America and Europe are still the largest markets globally, Asia is responsible for an increasing share of global vehicle sales and is the only major market expected to see continued strong growth in both the medium and long term.

5G also seems to simultaneously be a top priority on the political agenda. Currently Huawei, The Research Institute of China Mobile and China Mobile Shanghai are jointly conducting tests on the coordination of high and low bandwidth in a 5G network. The tests are conducted at the Huawei R&D Centre in Shanghai where test conditions have been developed to meet the requirements of a 5G system prototype. They provide the opportunity to test key technological solutions using a real network simulation. Moreover, they can also be used to present innovative services that 5G technology will enable in the future, with automotive-related uses being a top priority on the research agenda and Tele-operated Driving (ToD) currently the main focus. The process of 5G standardization is still ongoing - the first version of the 3GPP 5G network standard will be ready by mid-2018. It is therefore crucial to carry out research and verify technological solutions that will allow for the creation of a network standard characterized by superior, flexible parameters, one that will enable the digital transformation of the entire industry, now - at a time when China wants to enter the real 'Industry 4.0 era'.

It is also important to note that such intense involvement in coming up with the best possible standardization for 5G should not be surprising given China's ambitious roadmap for connected and driverless cars. Surprisingly enough, despite the fact that the country is a global market leader in terms of automotive industry size and in internet technologies, the development of clear regulation to support innovation in this area has been sluggish. The situation changed slightly in April 2017 with Chinese authorities issuing the Auto Industry Mid and Long Term Plan. This plan was jointly issued by powerful departments from various ministries. The draft includes technical standards for driverless cars across China and attempts to present a centralized jurisdiction of rulemaking regarding autonomous vehicles that could be easily used by others.

Further south, the Singapore government has identified the deployment of autonomous vehicles as one pillar of its 'Smart Nation' strategy and the Committee on the Future Economy (CFE) has encouraged the government to promote increased R&D in the area of self-driving vehicles - highlighting AV technology as a key innovative urban solution to be potentially used in e.g. (air)port operation. What is more, unlike some other countries where private-sector tech giants or automakers are driving the R&D of AV technology, it is the Singapore government that is taking the lead in the innovation contest.

Japanese Prime Minister Shinzo Abe perceives 5G-enabled autonomous driving as a key innovation driving economic growth amid a 'graying society'. The Government published the 'Public-Private ITS Initiative/Roadmaps' in 2014, and revised it in 2015 and 2016 to accelerate the schedule. Japan is looking to promote driverless cars in the run-up to the 2020 Tokyo Olympics and Paralympics during which 5G technology is supposed to be fully commercialised. The goal is therefore to have intermodal transport and self-driving taxis operational at the Olympics. Like in many other countries, legal issues and the implementation of new Mobility as a Service (MaaS) and safety regulations remain the key challenge. In April 2017, the authorities in Japan unofficially approved a draft set of rules for testing driverless cars on public roads with the vehicles being monitored remotely. According to this new legislation, a company must comply with certain conditions to receive a test permit i.e. the technology must be tested on a track, the vehicle is required to have an onboard telecommunications system and driving conditions during testing must be monitored remotely with the same degree of precision as by a person sitting in the driver's seat. Based on this draft set of guidelines, Tokyo plans to make necessary legislative revisions and have them passed during an ordinary session of the National Diet session in 2019.

In South Asia, where the average labour productivity of 500 automotive firms surveyed in India by the World Bank was less than one-third the level in China, with Pakistan further behind, the situation is significantly different. The aforementioned report additionally makes note of the fact that low productivity also reflects high skill gaps between the automotive industry in South Asia and other regions of the continent – among both production workers and their managers. Thus, the automotive industry holds the promise of not just improving South Asia's global competitiveness, but also creating sustainable, inclusive job and entrepreneurship opportunities in the region. A CAD system is however, at present, nowhere to be found. The challenge for countries in South Asia is to spread and democratize the excellence they have been able to achieve – in patches – more broadly and consistently and then build on the expertise of their Asian partners in making automobiles more connected.

To sum up - Singapore, Japan, Korea and China have all decisively joined the global race of 5G usage in the automotive industry. When taking into consideration local specificities, there are clear differences in the approach to autonomous vehicles that is being taken in Singapore and wider Asia as compared to the US or Europe. Given the local conditions the push for AV innovation tends to focus on first-and-last-mile and intra-town travel transportation - coinciding with the growth of many megacities in Asia. That might be an interesting space for MaaS which is still neglected on the most populated continent.

# Europe: still in the game

Europe's automotive industry provides jobs for 12 million people and accounts for roughly 4% of the EU's GDP. Although the industry is the largest private investor in R&D worldwide, 80% of growth in the industry is expected to occur outside the EU – this due to export volume. The industry is also under heavy scrutiny following the 'dieselgate' scandal. With new business and ownership models as well as pressure to digitalize and decarbonize - the industry needs to reinvent itself and create a new paradigm for Europe's mobility ecosystem. The deployment of 5G will be a great opportunity to do so.

To that end, CAVs are now a priority on EU's agenda and all major European automotive OEMs are actively developing, adopting and scouting these new technologies. This is particularly important because, in Europe, connected cars are seen as gateway to future of automobile industry. In addition to wireless LAN devices, connected cars have active safety solutions and Automated Driver Assistance Systems (ADAS).

Research indicates that, following 2010, the market for connected cars, while still in its nascent stage, has been growing each year. Given the wide range of potential opportunities it presents to both the automotive and telecom industry as well as consumers, the market is expected to experience mass penetration and witness substantial growth in the near future. Europe, which is currently the second largest market for connected cars, is estimated to outpace North America and create the largest market by the end of 2020. The rising demand for vehicle safety and security will continue to be a key driver for market growth.

The market is predicted to gain traction due to widespread adoption of mobile and wireless technologies. Some governments within the EU are introducing various regulations and initiatives regarding vehicles safety, which could prove to be favourable for connected car manufacturers and dealers. The growing availability of advanced telecom and road infrastructure will also continue to fuel the European market for 5G-enabled CAVs.

Given the absence of regulatory clarity on the EU-level, individual MSs are left to regulate these matters independently. EU leaders seek to remedy the situation through a multi-level dialogue involving both government and industry leaders. Examples of such initiatives include the 'Gear 2030' High-Level Group (composed of the EC, MSs, auto industry leaders, trade associations, representatives from the insurance sector and other stakeholders), the UNECE platform or EU-Japan dialogue, the Amsterdam Declaration on self-driving cars as well as the EU's strategy to promote free flow of data and to digitize industry as part of its effort to create a Digital Single Market (DSM). The most concrete achievement in this area to-date is a Master Plan on C-ITS published in November 2016 which seeks to facilitate the deployment of C-ITS services by 2019. The Commission also supports a countless number of R&D projects under the Horizon 2020 (H2020) research framework.

Car manufacturers will also need long-term, compatible mobile partners and that is currently a challenge. A recent survey concluded that many consumers from the UK, Netherlands, Germany, France, Sweden, Spain, and Italy are concerned about the lack of standardization across connected car manufacturers. This is anticipated to be a major barrier on the market - causing significant reluctance among consumers with regard to data privacy and digital safety. A sizeable consumer population still prefers to personalise their car's web connection via smartphone, USB or Bluetooth rather than buy a connected car with built-in connectivity features. This is another factor that could be a major roadblock on the market. Furthermore, many people are not yet ready to pay a separate, additional charge for a car-embedded internet connection - which is foreseen to cause a setback for the market in Europe.

Compromising all of the interests in what is a highly politically sensitive area will be a big challenge for the EU. Europe will seek to protect jobs while creating conditions for future success in CAD and autonomous driving. It will enable the sector's transformation and deliver significant consumer benefits and follow through on its DSM strategy, finally moving towards a true European Gigabit Society by 2025. Thankfully, the EU seems to finally understand that regulatory challenge and slowly but steadily starting to act in order to excel in the EU-US-Asia competition.

# Insights from three case studies

The section below presents 3 case studies selected based on their importance on the EU policy agenda. Each of them depicts how the deployment of 5G will enable ICT-related developments and transform a particular aspect of the automotive industry. This will ultimately contribute to development of more connectedness and automation as well as create new business models and opportunities for passengers and consumers alike.

## 5G as enabler of enhanced V2X communications for connected cars and automated driving

CAVs enabled by 5G with highly reliable onboard applications accessing ultra-low latency, widely available and ultra-secure networks will create significant market growth opportunities. According to GSMA estimates, the total global revenue for the connected car industry stood at $37.5B in 2015 and is predicted to increase to $151.8B in 2020 - driven by new safety and security features as well as infotainment and navigation services that rely on or augmented by a mobile connection, particularly in Europe. Advanced sensing, communication and computing technologies should be integrated into vehicles to improve safety statistics and save lives. Moreover, these technologies will also enable fully autonomous driving – and that will greatly transform the entire transportation.

Many of the use cases have to do with what are still emerging markets (i.e. sensors for autonomous vehicles) so growth will be dependent on market innovation and development of appropriate regulation as well as the deployment of 5G networks. As a result, it may be a while these markets experience dynamic growth. That said, given the broad implications of some of these use cases, the overall impact to society is expected to be tremendous. Producing completely new inter-connected tools and sections while ensuring their security will therefore become a big challenge for all auto makers. This essentially creates a need to find solutions that work on the entire planet. Because of that a significant lead time will be required before an auto manufacturer can release models that are capable of driving autonomously in most parts of a given continent or, in the US, even a single state.

The idea of vehicles sharing information and working together to make transportation safer, greener, and more enjoyable, is, nevertheless, truly compelling. The technologies associated with the concept of C-ITS, promise to reduce traffic congestion, lessen the environmental impact of transportation and significantly reduce the number of fatal traffic accidents. Just the technologies impact on safety alone makes C-ITS worth considering – bear in mind that according to the 'Global Status Report On Road Safety' published by the World Health Organization (WHO) roughly 1.25 million people died in 2015 as result of traffic accidents which also generated associated governmental cost of about 3% of GDP.

A key enabling technology of C-ITS is wireless communication, encompassing vehicle-to-vehicle (V2V) communication, vehicle-to-infrastructure (V2I) communication and infrastructure-to-vehicle (I2V) communication. Collectively, these wireless transactions are referred to as V2X communication. With the emergence of 5G these connectivity opportunities are believed to augment and enhance the capabilities of autonomous vehicles2. It is through this mechanism that social benefits, which in many cases can be easily translated into what economists call gains in output, will be achieved. At the end of the day, V2X increases vehicle safety, enhances driving efficiency, saves money, and helps reduce traffic accidents – just to name a few of its benefits.

Trucks are expected to be the first to go driverless. On the one hand, this is because they drive mostly where conditions are substantially more technology-friendly, on the other however, they also present the most interesting commercial activity. Though the first step will no doubt be convoys following a lead vehicle driven by a human – the next one is sure to be fully independent automated trucks. And given the fact that city infrastructure will be simultaneously adjusted to this new status quo – private cars are expected to follow.

The EU is already aware of and fully appreciates the opportunities stemming from V2X connectivity. A pan-Europan portal on CAD has been launched, following the 1st European Conference on the same topic. On September 30, 2016 at a Roundtable on CAD which was initiated and chaired by Günther H. Oettinger,

[2] In this study, autonomous vehicles refer to vehicles that have significantly more autonomous capabilities relative to the existing stock of vehicles. They are not however necessary 'level 5' fully autonomous vehicles as defined by the most common level 0-5 scale. Some autonomous capabilities could, for example, include functionalities that are sometimes referred to as ADAS (Advanced Driver Assistance Systems).

European Commissioner for Digital Economy and Society, the automotive and telecom industries from the whole continent formally announced the creation of the European Automotive Telecom Alliance (EATA) the main goal of which is to promote the wider deployment of CAD in Europe.

In February 2017, the EATA presented a CAD deployment roadmap which includes its pilot projects and its on-going regulatory dialogue on connectedness and future autonomous vehicles. The Alliance also announced that it has submitted a proposal for funding for the Connecting Europe Facility which is aimed at ensuring a speedy development of CAD across Europe. By leveraging the latest technologies, the EU can deliver smarter, safer and cleaner transportation and strengthen its competitiveness on the global stage.

It is also important to note that Commission President Jean-Claude Juncker has identified driverless vehicles as an area where the EU can deliver tangible benefits to citizens. In his five-scenario white paper on the future of Europe, published in March 2017 ahead of the EU's 60th anniversary summit in Rome, CAD was used repeatedly as an example of something that cannot become a reality without the EU and its transparent regulation. In fact, various research projects, also those funded as part of H2020, are already in the works - with BigDataEurope, VI-DAS, INLANE, CARTRE or AUTOPILOT being just a few arbitrary examples.

V2X is sure to be a significant enabler of 'level 5' automation. Improved sensory abilities of vehicles will, for instance, likely be an important factor in determining when and if full autonomy is achieved. Once at stake, additional value can be created through providing information, entertaining experiences and productive tools onboard autonomous vehicles. The extent to which additional value is provided now depends mostly on regulators.

# Revolutionising passenger experience with Mobility as a Service (MaaS)

With the integration of connectivity in cars new business models have already started to emerge. These are spurred by the availability of eCall in Europe and with the rapid growth and penetration of 4G technology which, in turn, enables a host of telematics and security applications. This transforms the relationships between car manufacturers and network as well as technology and services providers such as insurance, driver assistance, security or content delivery companies. 5G will benefit from this trend and see a multiple new partnerships which will also be facilitated, among others, also enabled by the enhanced safety, mobility and environmental stewardship that characterizes 5G networks. In this context, it is extremely important to keep in mind all aspects, related to cars, intelligent and connected transportation infrastructures, technological as well as connectivity solutions and finally the data all of this generates.

5G cellular systems are expected to enable a major digital transformation that will provide people, businesses and governments with unprecedented capabilities to share real-time information. The industry consensus is that 5G should be known not only for its cutting-edge radio access technologies but also for the way it integrates cross-domain networks so operators can provide networks on a need-for-service basis. Currently, travelling by car is the only form of mobility that guarantees to comfortably connect you to any destination at any time. No other mode of transportation is capable of this. But if you put together all the traditional modes of transportation such as public transport, taxi and car rental and services such as car shares, ride shares and home deliveries you might be able to make the same dream of freedom in mobility, that today comes only from owning a car, come true – without all the hassle that comes with it.

Next-generation 5G networks will cater to a wide range of new business opportunities some of which not even been thought of yet. True deployment of MaaS, also called a Netflix of transportation, is surely a good example of that. Some already see it as a phenomenon that could potentially disrupt not just automobile manufacturers (through its effect on the demand for owning cars) but also the broad category of transportation providers as a whole (e.g. what if bus service could be obtained 'on demand' or buses could have more flexible routes depending on traffic patterns and the location of customer demand?).

According to Sampo Hietanen, CEO and founder of MaaS Global which is the world's first ever mobility operator, MaaS is not just about solving 80% of trips for 80% of people; it is about delivering a complete mobility to as little as one individual – mobility that, up until now, could not be handled easily. Simply providing efficient connectivity will not be enough to convince the end users. Passenger experience needs to be carefree and MaaS

operators need to have enough supply. But if these conditions are met, MaaS can simplify passenger experience in several ways. Passengers can register just once and be able to use any mode of transportation - this instead of having many different apps for their daily mobility. Payment for these services can be simple because payment information needs to be added only once to use all of the services.

One should think about the scale of Uber's successes in recent years; the $70B company has built a truly global brand which is dynamically revolutionising personal transportation. Its approach has been adopted by a long tail of smaller competitors in a number of regions. Uber's dominance of the ridesharing market is demonstrated in the way that the brand has been 'verbified' with the term 'uberization' – which refers to the migration of an industry into a shared-economy services business model. Impact made by MaaS will be undoubtedly significantly bigger.

Because it understands what the MaaS concept might bring, the EU is pushing its policy agenda in this regard. The current EC-funded research projects on mobility services include MOBiNET and SPICE. It addition to this, an innovation platform, called European MaaS Alliance, has been founded to work on coming up with a common approach to MaaS across EU countries. The MaaS Alliance is a public-private partnership (PPP) which is creating the foundations for a common approach as well as unlocking the economies of scale needed for successful implementation and growth of MaaS in Europe and beyond. The main goal is to facilitate a single, open market that allows for full deployment of MaaS services.

Several tailored MaaS initiatives are planned or initiated across Europe. Through a shared work program that involves transport operators, service providers and users, the MaaS Alliance will help them all cooperate with each other. Finland is a pioneer in the area of mobility servitisation and strongly contributes to promoting the MaaS concept not only in Europe but also around the world. In fact Helsinki is the very first, and one out of two cities total, where the Whim app, which frees a person to travel wherever and whenever he/she chooses with access to more than 2500 taxis, brand-new rental cars from Sixt and HSL public transport – all in a single mobile app, is available. The application provides all the routes, fees, tickets, timetables, booking and travel options in one place so that you can focus on the essentials.

5G platforms will, in a nutshell, reduce the dependence of travelers on predictable and pre-planned modes of travel. And, by enhancing the attractiveness of 'on demand' or shared ownership services, they might also cause a decline in the demand for ownership of passenger cars. It is also possible that the rationale behind owning a car might change – from a critical need or at least important means of getting around to an increasingly non-essential source of leisure. The extent of its impact on car ownership will depend on whether the MaaS phenomenon will be focused on areas where there are already good alternatives to car ownership (European cities) or areas where alternatives to car ownership are currently underdeveloped or not cost-effective (European countryside).

# Evolution of cooperation between players from the automotive and ICT industry

For the next decade and beyond, 5G will support growing connectivity needs - enabling the launch of new services, connecting new industries as well as devices, and facilitating new user experiences. GSMA in fact predicts that the annual sales of connections for automobiles will reach 91 million units by 2025 – reaching such ambitious sales targets will no doubt require holistic cross-sectoral cooperation.

Some producers and OEMs already know that solutions they are currently offering, are lagging behind. As a result, they are putting significant pressure on their R&D teams. But will traditional automobile manufacturers be successful in their efforts to join in and provide what have traditionally been viewed as services or extra features of the core vehicular experience? Will they become successful 'system integrators' or will this mantle instead fall to newly born tech-firms that effectively outsource the manufacturing of the vehicle to established players in the automobile industry?

Although the questions above are still to be answered cooperation between players representing the automotive industry and the ICT sector is already a fact. Apart from the EATA and European MaaS Alliance, which have already been mentioned above, some other cross-sectoral associations have been created. The ETSI Industry Specification Group for Mobile Edge Computing has grown from an initial 6 to over 40 members within less than

a year of inception. At its heart mobile edge computing is an enabler of enhanced V2X communications for CAD because it increases road safety and optimises the investments into infrastructure.

The best illustration of cooperation between all the relevant market players can be seen in the launch of the 5G Automotive Association (5GAA) which happened in September 2016. This global cross-industry organisation, consisting of companies from the automotive, tech and ICT industries, works together to develop end-to-end solutions for future mobility and transportation services.

5GAA unites 55 members, mainly from Europe, including 8 founding members: AUDI AG, BMW Group, Daimler AG, Ericsson, Huawei, Intel, Nokia, and Qualcomm Incorporated. Diverse in terms of expertise, 5GAA's members are committed to bridging the gap between the automotive and communication industries in order to develop, test and promote connected mobility solutions as well as initiate their standardization, accelerate their commercial availability and increase global market penetration.

A white paper from 5GAA elaborates on why Cellular-V2X (C-V2X) technology at the radio level is an essential enabler of connected transportation services throughout the world. The 5GAA perspective is that 3GPP-based cellular technology offers superior performance and more future-proof radio access than IEEE 802.11p and can leverage ETSI-ITS, ISO, SAE and IEEE upper layer standards and tests that have been refined by the automotive industry and others in the ITS community for more than a decade. Such powerful lobbying for radio level technology has not only, for the time being, blocked satellite system development but also, perhaps most impressively, united players whose collaboration was unimaginable just a couple of years ago.

The ecosystem brought to life by the long awaited meeting of 5G and V2X communication requirements will, overall, create new business models that disrupt how vehicle manufacturers and ICT companies currently function. Cooperation between OEMs and telecom operators will reduce cost related to development of infrastructure while at the same time decreasing barriers of entry – allowing other sources of data to join the ecosystem. This in turn will increase the set of data that can be used to build the Local Dynamic Maps (LDMs) in cars. As a ubiquitous means of connecting all data sources and a creator of the need for this data to be shared by business from different industries (in order to create truly automated driving solutions), 5G will generate new opportunities and lead to the development of new services which have not yet been thought of. Which is still more proof of the revolutionary potential of 5G as a GPT.

# Making change happen

The impacts of 5G on the European automotive industry, as discussed in this study, function in a variety of political-economic contexts and have very different origins in terms of the players and sub-sectors that instigate and lead the transformation. Various sub-sectors also have different objectives, problems and policy issues that have to be dealt with before implementing 5G solutions. That also means that, while they all stem from ICT and 5G infrastructure, the set of enablers for each category is different and functions in its own context. Some common processes for enablement have, nevertheless, emerged while analysing the distributive impact of the technologies studied. It is certain that the processes are less about how and by whom the policy was initiated and more about building an effective implementation process. A number of ways in which these enablers could be harnessed or missed were, in addition, identified in the case studies. A list of comprehensive conclusions and recommendations relevant to our case studies have been created based on the matrix described above.

# Conclusions

This study has illustrated how disrupted and enriched the European automotive industry will be with the full deployment and commercialisation of 5G technology. There are still noticeable differences across European countries in their approaches to respond to technological challenges from a regulatory point of view. That said, given the continuous progress and investment into infrastructure, 5G is positioned to be a critical driver of innovation, productivity, competitiveness and inter-sectoral spill overs. Rather than just being a source of mass employment in traditional production as such, it can help in meeting social and environmental goals like reduced Green House Gas (GHG) emissions and modifying customer behaviour. Calling 5G a GPT, which is what IHS Markit analysts did, does not seem to be an exaggeration.

It can be said for certain that 5G will have a disproportionate impact on several types of businesses; some will benefit more than others, and some will initially be hurt by it due to the disruptions it will cause in their existing production, distribution and marketing processes. Most of them will join forces creating new business models. However, even without concise regulation at the European level, the majority of the automotive industry and its users and passengers seems to benefit from 5G enormously. And that is not just in terms of the further development of MaaS and self-driving cars but also in relation to greatly enhancing the connectivity options of traditional vehicles.

One particularly intriguing advancement will be related to the ability of vehicles to communicate directly with each other – potentially giving them the power to automatically avoiding crashes or minimizing damage. It will be the commercial vehicle segment that will first to see major changes though - particularly those that relate to optimizing trucking operations. The net gain for consumers in this case will ideally be lower prices due to lower logistics and shipping costs.

It is very likely that CAVs equipped with the best quality sensors will also play a significant role in the insurance business - not only as a tool for determining what happened during an accident but also one that can dramatically reduce the occurrence of crashes and impact repair costs. In is in fact not just insurance that this technology could revolutionise - it impacts many different industries including retail, computing, mobile phones, health & safety and social networks some of the most obvious among them. In healthcare, for instance, some European car brands are already working with healthcare experts to develop basic but reliable technology that monitors driver health. It is also worth noting that, according to Chris Kreinczes, a consumer behavioural analyst from Canvas, in the future cars will become key health monitors offering a range of benefits - from acute trauma prevention to managing chronic diseases by determining lost motor function and acting appropriately (perhaps by safely bringing the car to a stop when needed).

Given all of the above, the author sees numerous policy areas that need addressing if we are to ensure that 5G generates a positive impact on the European automotive industry. The recommendations discussed below have been divided into three categories: those relevant for EU bodies, those regarding ideas to be implemented at the national level, and those to be considered by OEMs and ICT industry players. The division between first two categories is obviously less solid due to the interconnected regulations of Brussels and MSs capitals. It should be recognized that both policy recommendation types focus primarily on regulatory aspects and should be recognised as complementary.

# Recommendations

## Possible support to be provided at the European level

- Launching public consultations related specifically to the impacts of 5G on the automotive industry where both ICT and car producers would be top target groups. Only extended questionnaires from the executors will aid regulators in their policy design tasks and help the EU to win the 5G worldwide competition.

- 5G can provide cost-effective solutions to the entire society and truly contribute to achieving the Gigabit Society vision – a flagship initiative of the EC. The better we define use cases, the more industries and citizens will be able to tap into new societal and economic opportunities. In this context, the public administration has an opportunity to act as an early adopter of 5G technologies, for example, through public procurement which would in turn help build a sound business case for the required investment in automotive infrastructure.

- While the mobile communications markets, which are fragmented on a national level, united in a European regional effort through GSM, the ultimate result of the global deployment of 5G is a process that requires global alignment and a common set of specification. Through the transition from ETSI to 3GPP, a global platform was established for the defining specifications of the next generation of mobile communications - starting with UMTS. With the global adoption of LTE the need for 3GPP2 covering the USA, based 3G specification, has ceased to exist and 3GPP became the de facto global platform of the 5G specifications effort. Through the RACE research program the EU established a firm foundation for working on the next generation of specification – which has continued through 4G and into the 5G era with e.g. the METIS projects. This thought leadership of the European industry is broadly recognised and should be promoted across all MSs.

- Innovation architecture matters. One should remember that absorption, diffusion as well as supply and demand of R&D have a direct impact on sustainable growth. In this regard, the EC should maintain the priority status of 5G R&D, especially on automotive solutions, launching new H2020 opportunities in the next call.

- Europe should support a standardization system that respects a variety of innovation business models within automotive industry, in particular, ensuring reasonable intellectual property protection and adequate returns on investment. This is an important guarantee if an industry is going to invest billions of Euros in developing innovative technologies. The support can be practically shown by actively promoting standards that meet the requirements of openness, interoperability and consensus.

- There should be close coordination between European Standards Organizations (ESOs), as well as other Standards Developing Organizations (SDOs) so that existing standardization efforts related to the deployment of C-ITS can be leveraged. This can be done, for example, by integrating 3GPP/ETSI timelines related to 5G development.

- Spectrum regulatory policies also have an enabling role to play. The 5.9 GHz spectrum band is being considered globally for ITS and safety applications – and also for the above mentioned V2X communications. In Europe, for example, the 3.5 GHz spectrum is useful for augmenting V2X operation in 5.9 GHz to support network-based 5G automotive use cases with high bit-rate usage - thus facilitating many broader industrial and consumer-oriented applications. Given the 'mission critical' nature of some automotive applications the timely release of a sufficient amount of dedicated spectrum for ITS, appears to be important in this case - especially as it relates to the future of CAD.

- The EU needs to cooperate internationally to harmonize and quickly make available a radio spectrum for 5G. Specifically the 700 MHz band which is part of the 470-790 MHz range that is currently widely used for digital television broadcasting and wireless microphones at various events and the 700 MHz band and its current availability in many EU MSs both represents the potential to lay the stepping stones for developing spectrum policy that will benefit 5G in the future.

- The EU will have to acknowledge the situation of evident regional concentration of capacities, eyeing the tech generation, especially in emerging fields. At the same time, it will have to leverage the existing potential more broadly to include more than the ecosystems of existing frontrunners – which already make use of advanced manufacturing technologies on extensive international level. The identified regional disparities with regard to industrial modernisation should be tackled by facilitating integration into European value chains. Emerging technologies that do not come from the industries core players should be supported. This would not only ensure a broader distribution and adaptation, but also support and boost the efforts of Europe's leading industrial stakeholders. Research, evaluation and reporting related to Cohesion policy needs to include the topic of older industrialized regions – with a focus on the specific problems facing these areas. Efforts should be made to identify these kind of areas, especially those directly related to automotive industry, and provide information on their long-term development as well assess the success or failings of reconversion strategies being implemented on them.

- The re-use of ITS infrastructure by mobile operators deploying 5G, perhaps even through collaborative efforts that supersede any business related obstacles related to such deployments, would be another important policy measures that would generate benefits.

## How 5G deployment in the automotive industry would have to be supported at a national level

- National regulators need to address security, integrity, data protection, and privacy in the data economy in a holistic manner from a user's point of view, in particular, by putting in place rules that apply to all providers of 5G automobile applications offering equivalent products and services.

- 5G will be the first mobile technology that has been developed vertically - with and by the end-user industries. One such example is the cooperation between automotive manufacturers and telecommunications operators to achieve widespread rollout of connected car applications. This approach needs to be accompanied by a similarly innovative approach to forming government policy – one which facilitates the digitalization of these vertical sectors. The safety-related connected car applications highlighted in this report may not be launched without government intervention to provide these services with a public safety mandate.

- Regulation should recognize that consumers and users have radically changed their habits related to mobility. They crave for data connectivity, communicate intensively via app-based services and want more of these new services - from more players. MSs need to look at how to facilitate the creation of new business models, such as MaaS, from more players. This is why, when it comes to 5G, simplified horizontal legislation is a key enabling force – also as it relates to the Internet of Things (IoT) related services. Double-regulation regimes, as such, will undermine innovation and selection as it goes well beyond the horizontal protection already provided by the General Data Protection Regulation (GDPR).

- Privacy protection: Personally Identifiable Information (PII) is any information such as one's name and phone number that can be used to distinguish or trace an individual's identity. PII in MaaS may be disclosed but only given the individual's knowledge and consent.

- Policies that promote innovation and reward investment in communication networks and innovative standards are needed as is preserving a technology-neutral approach on use of spectrum. European investment in networks has indeed been decreasing over the past few years as a result of falling mobile revenues and profits – a dangerous trend for Europe's digital future. The new regulatory framework under the DSM needs to make sure that operating a mobile network remains a profitable business. This is paramount for EU capitals as it is the number one condition for the emergence of 5G in automotive industry.

- Wireless network operators should, in general, be allowed by MSs to invest in network capacity and improvements with the assurance that they can offer specialized services to end users – in particular IoT services like connected cars – that are based on specific commercial agreements and Quality-of-Service levels. The stimulation of network investment should be ensured through a full review and revision of the regulatory framework for telecommunication services so as to reduces sector-specific ex ante regulation and ensures a level playing field among market players in the digital value chain.

## Measures to be taken by carmakers, OEMs and other key players in the automotive and ICT industries

- Shifting the momentum of the mobile communication industry from leaders in consumer markets to leaders in services markets for vertical industries is going to require a change in mindset in terms of strategic vision among all involved players. It requires a new industry logic to prevail. Top-down virtualisation should be implemented because it is the only process that can provide a technological opportunity that spans the whole continent. The collaboration and alignment of the automotive and telecom worlds is a must if leading European 5G technology is going to get up and running.

- Tailoring services to specific requirements (which to some extent are still unknown) of a particular subsector of the industry will take a lot of time and effort in terms of service concept development followed by business model development. Major investments for exploring new business types will be required from both the communications industry as well as the particular vertical industry involved.

- Successful launch and adoption of 5G-based services requires a critical mass in order to provide investors with a commercially viable business case – wireless networks, mobile devices, smart applications and digital services need to be established on a pan-European level - with corresponding investment policies supporting available infrastructures like fibre backhaul. This in turn requires coordinated timing for the launch and rollout – which should be agreed on with the EC ahead of time.

- The investment required to deliver 5G as well as the above mentioned fibre infrastructure throughout Europe in the coming decade is substantial, and will clearly require the involvement of private investors. In this environment, which will necessitate ever more capex intensive deployment of ubiquitous and dense network architectures, it is important that policy regarding competitiveness be put into place keeping in mind the fact that there is even more of a trade-off between the level of investment and the number of operators a market can sustain. Network sharing with so many moving vehicles will not be enough and major investment commitments will be endangered by unpredictable market outcomes arising from unstable or unsustainable competitive environments.

- Although this argument is relevant for 5G applications in general, security of the automotive industry is a crucial point here. That is why innovative schemes that ensure the requirement of security features should

be developed based on established security mechanisms. The demand for authentication and protection of private data as well as consistency and the ability to detect foul play need to be addressed in 5G V2X networks. The overhead introduced by the security features should be reduced and the timeliness related to authentication management should be ensured. The ubiquitous connectivity of vehicles envisioned for 5G V2X networks demands strong security mechanisms to prevent unauthorized access to vehicles and related personal data. The IEEE 802.11p systems used today offer basic authentication and provide mechanisms to protect private data. Its centralized management of certificates however, in combination with only sporadic connections between vehicles and infrastructure, leads to a long delay for certificate revocation and results in a large communication overhead. The 5G V2X approach should reduce this delay to enable a timely response to vehicles that are not behaving the way they should. Further development of security mechanisms should also reduce the overall overhead needed to provide security that supports the increasing numbers of connected vehicles which is expected to grow dramatically in the future. Physical layer security mechanisms might be an option that reduces overhead while maintaining the desired level of security.

- Vast amounts of data will be created in the 5G era - leading to the emergence of a user's digital personal identity and becoming the new fuel of the digital economy. Trust of consumers in a new user-centric paradigm is a key ingredient in successful development and implantation of 5G. A chain of trust throughout the mobile ecosystem based on secure systems and products should be imbedded in vehicle's hardware – starting at the level of the connectivity modem and continuing both vertically - from the modem to the mobile device (or machine) and horizontally - from the device (or machine) through the network to its edges and the Cloud.

- Providing V2V multi-link connectivity mechanisms to increase robustness and network coverage in case of delays - and reliability-critical deployment scenarios: Radio Resource Management (RRM) and Medium Access Control (MAC) should be flexible enough to leverage wireless network coverage whenever possible and enable streamlined downgrading as coverage becomes limited or non-existing.

- Designing novel discovery, synchronization and context-aware mechanisms are necessary to provide increased reliability/dependability of V2X communication links.

- Global engineering service provider, FEV, continues to push forward with its global 'smart vehicle' development efforts by establishing a global centre of excellence (CoE) focusing on the interdisciplinary development of connectivity and the automation of future vehicle development. The centre is however based in the US. The company's European counterparts should do something similar if they want to participate in the race toward 5G.

- In order to ensure service compatibility across networks, the industry is encouraged to establish an entity that can test and approve new applications for compatibility with the 5G standard and its APIs - much like the model of the Wi-Fi Alliance.

- Further development and collaboration within 5GAA and similar cross-sectoral associations to accelerate development of the infrastructure required for self-driving cars is needed. This collaboration is yet another example of Europe's, or more specifically Germany's, premium carmakers working together to build the technological expertise necessary to take on new rivals like Uber and Google – all which are also working on autonomous driving technology.

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