

Report on the diversification of the 5G ecosystem

09 December 2021

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1 Introduction

In 2020, BEREC published a radar¹ plotting the 5G related developments according to the anticipated time horizon with the aim of helping National Regulatory Authorities (NRAs) prioritize the regulatory aspects that might need attention. The radar identified a number of themes that BEREC and NRAs may look into in more detail in the coming years in order to address 5G related developments. The themes include: Convergence, EMF, End-user, Interoperability, New Business Models and Value Chains, Numbering, Privacy, Quality of Service (QoS), Roaming, Roll-out, Security, State Aid, Sustainability.

Following the publication of this radar, BEREC carried out a survey to determine from past and on-going 5G trials and pilots, which of the mentioned themes can be interesting to look into further. This survey took also into account that BEREC's Work Programme for 2021 was already exploring further some of the topics listed in the BEREC 5G Radar such as EMF, Sustainability and Security. The survey was completed by BEREC's members and participants who could consult with their national key stakeholders who were members of consortia that participated in 5G trials and pilots. Following the analysis of the information submitted, the theme 'New Business Models and Value Chains' was identified as the theme which should be explored further. Moreover, BEREC was also seeking to determine the anticipated pace of innovation.

Thus, BEREC organised a public online workshop on 5G² which consisted of two panel discussions – one on 'New Business Models and Value Chains' and the second on the 'Anticipated Pace of Innovation'. The first panel on 'New Business Models and Value Chains' brought together stakeholders representing some of the key players which will form part of the 5G ecosystem and who are experts in the possible diversification that 5G may enable. The panellists were: Mr. Wreschner, Vodafone; Mr. Bonifay, Transatel; Mr. Summer, Ericsson; Mr. Pujol, Cellnex Telecom; Mr. Budnik, Thein; and Dr. Matinmikko-Blue, University of Oulu. The second panel delved more on some of the 5G pilots and trials to address the question of when we should expect 5G use cases to be launched commercially. The panellists were: Dr. Willcock, 5G Infrastructure Association (5G IA)³; Dr. Siddiqui, 5G Zorro⁴; Prof. Bernardos Cano, 5Growth⁵; Dr. Hetzer, 5GCroCo⁶; Dr. Pagano, COREALIS Project⁷; and Mr. Neira Rey, AXON Partners Group.

¹ BoR (20) 223 See: https://www.berec.europa.eu/eng/document_register/subject_matter/berec/others/9721-guide-to-the-berec-5g-radar-and-5g-radar

² See: https://berec.europa.eu/eng/events/berec_events_2021/282-berec-workshop-on-5g

³ <https://6g-ia.eu/> - 5G IA represents the private side of the 5G PPP with the European Commission representing the public side.

⁴ <https://www.5gzorro.eu/>

⁵ <https://5growth.eu/>

⁶ <https://5gcroco.eu>

⁷ <https://www.corealis.eu/>

The BEREC 5G Radar⁸ identified a number of sub-themes related to the theme “New Business Models and Value Chains”. Whilst taking into account the information provided and the statements made by the panellists, this report will delve deeper into the following sub-themes of the BEREC 5G Radar:

- New business opportunities
- Creation of new wholesale markets
- Private/local networks
- Network slicing and 5G wholesale markets

Annex I contains an extract from the BEREC 5G Radar related to these sub-themes.

The aim of the report is to highlight the key remarks made by the speakers relevant to each sub-theme which may impact BEREC’s future work with the widespread adoption of 5G use cases. The report also seeks to provide BEREC’s preliminary perspective on how BEREC’s future work may be impacted with the anticipated changes and the anticipate pace of innovation.

2 New Business Opportunities

Various key players who have already invested in this new generation of mobile connectivity are actively working on monetizing on the investment made. Their focus is on the commercial launches and market uptake of 5G use cases that profit from 5G technical novelties such as mobile edge computing using distributed cloud solution, network slicing or the enhanced features of 5G private networks. Mr. Wreschner, Vodafone, claims that the connectivity sector is no longer a stand-alone sector and its success relies on partnerships. For example Vodafone is collaborating with cloud service providers such as Amazon Web Services (AWS)’s Wavelength or the Microsoft Azure Stack to deliver ultra-low latency at the edge of Vodafone’s network⁹. The expected need for higher network densification in heterogeneous areas, such as small cells in smart cities or edge computing resources in connected factories, is also targeted by infrastructure providers acting as neutral hosts.

Mr. Bonifay, Transatel, stated that 5G may stimulate the proliferation of cellular connectivity for laptops and tablets via Embedded SIMs (eSIMs). eSIMs though integrated permanently into a device are compliant with all operators, rewritable and can be managed using remote SIM provisioning thus simplifying the process of switching between communications service provider and can also roam internationally¹⁰. Mr. Bonifay, highlighted how eSIMs installed in

⁸ BoR (20) 223 See: https://www.berec.europa.eu/eng/document_register/subject_matter/berec/others/9721-guide-to-the-berec-5g-radar-and-5g-radar

⁹ <https://www.fiercewireless.com/operators/vodafone-deploys-aws-wavelength-london-plans-for-dusseldorf>

¹⁰ <https://www.aeris.com/news/post/how-esim-technology-will-grow-with-the-coming-of-5g/>

laptops and tablets will eliminate the need to create a hotspot using a mobile phone or scan for public WiFi, resulting in enhanced security.

As envisioned in various studies, including BEREC's 'Study on Implications of 5G Deployment on Future Business Models'¹¹, the 5G supply chain is seeing the emergence of new players. One of the new emerging players is Thein, an investment group that seeks to help deliver custom solutions such as private 5G networks to 5G verticals. Moreover, new players which may influence the competition in the 5G supply chain are software developers and hardware manufacturers that are coming together to develop interoperable and thus vendor-neutral, disaggregated components such as Open RAN that rely on open interfaces and standards. Mr. Wreschner, Vodafone, stated that Open RAN promises to increase competition in a specific part of the supply chain which could also lead to enhancing European sovereignty and provide greater control in key parts of the network. However, the need for collaboration was re-iterated here. As an example of this need, reference was made to Vodafone's agreement with Deutsche Telekom AG, Orange S.A., Telefónica S.A. to support the rollout of Open RAN¹².

In terms of market shares, Mr. Summer, Ericsson, remarked that this is a consequence of both operator's commercial decision and the number of vendors available during the vendor selection process. The decision taken is not solely related to openness but also to performance, security and efficiency, with the latter being closely linked to the use of energy and the Green Deal. Moreover, it is important to look at the ability to develop other products for the next generation and thus scale and global standards play an important role in this process too.

The 5G ecosystem may also experience diversification with the adoption of emerging technologies. Dr. Siddiqui explained how 5GZorro is integrating Distributed Ledger Technology (DLT) and Artificial Intelligence (AI) at the system level i.e. part of the 5G system in order to enable smart contracts for ubiquitous computing and connectivity. The 5GZorro consortium is looking into how emerging technologies can be used to facilitate infrastructure sharing enabling zero-touch automation and security. The 5GZorro consortium is also working on a use case that explores how the 5GZorro platform can be used for spectrum trading and leasing.

This idea is supported by the work of 5Growth who stated in one of their deliverables¹³

"In the future, operators will provide a large variety of services based on NFV artefacts, creating heterogeneous layers to offer tailored services to verticals. In this context, operators will increasingly rely on other operators to extend their portfolio (e.g., lack of coverage of a certain area, or even secondary connectivity for reliability purposes).

¹¹ 'Study on Implications of 5G Deployment on Future Business Models,' BoR (18) 23

¹²<https://www.orange.com/en/newsroom/press-releases/2021/major-european-operators-commit-open-ran-deployments>

¹³ https://5growth.eu/wp-content/uploads/2019/11/D2.1-Initial_Design_of_5G_End-to-End_Service_Platform.pdf

New business models will emerge, bringing new players to the arena (e.g., service providers). This not only allows service provisioning to verticals to be done relying on the composition of network pieces from multiple operators, but actually empowers verticals to take upon themselves to realize such multi-domain composition, based on open APIs made available by the operators. In such a complex ecosystem, flexibility is of vital importance to enable the interaction with each other at different layers of the service “stack”.

During the BEREC Workshop for 5G, BEREC has been urged to continue monitoring the competitive conditions in order to avoid the introduction of new bottlenecks and risks of competitive constraints. Moreover, appropriate levels of intervention should be sought where there isn't competition. It was also remarked that as the three 5G use cases – enhanced Mobile Broadband (eMBB), massive Machine-Type Communication (mMTC) and Ultra-Reliable Low Latency (uRLLC) – have differing technical objectives, may give rise to different categories of data which would have different effects on the Mobile Cost models.

Dr Matinmikko-Blue from University of Oulu, who has carried extensive research on the interplay between regulation and the mobile communication business ecosystem¹⁴, highlighted how a local licensing model can help new entrants succeed in the telecoms market. The observations of the research team led by Dr. Matinmikko-Blue is based on a review of the regulation and spectrum-management approaches and also on the observation that one cannot deploy a network without spectrum.

Another point which was highlighted during the workshop is the role that Small-Medium Enterprises play in driving innovation in Europe both in the development of the 5G technology and in the applications which will rely on 5G. Mr. Neira Ray, AXON Partners Group, mentioned the challenges which these new players in the 5G ecosystem face including the fragmentation of the demand and supply across Europe when compared with the situation in other parts of the world, resulting in a challenge for these companies to scale. BEREC was urged to contribute to the development of policies that will help with achieving a homogenous 5G market.

Regulatory considerations and BEREC's future work

Given the nascent stage of commercial launches of 5G, especially those relying on uRLLC and mMTC, and the development and standardisation of new technologies which may further influence the 5G ecosystem such as Open RAN, with the possibility that in the future openness and interoperability will also target core networks, BEREC will continue to observe the 5G ecosystem. BEREC's aim remains to safeguard and promote competition. In doing so it will also take note of new developments, studies and also consult with key stakeholders to support an effective, proportionate and timely regulatory landscape that will safeguard competition throughout the 5G ecosystem that falls within its competence.

¹⁴ “On regulations for 5G: Micro licensing for locally operated networks,” M. Matinmikko et al., Telecommunications Policy 42 (2018) pp. 622-635

Despite the changes 5G will bring, BEREC recognises the benefits of regulating in a technology and service neutral approach. However certain applications will require the use of licensed spectrum especially when spectrum must be free from interference in order to provide reliability guarantees. While BEREC notes the recommendations made by some of the stakeholders in terms of treating WiFi and 5G similarly, one must acknowledge that unlicensed spectrum may not be able to provide the same reliability guarantees as licensed spectrum.

BEREC will also seek to safeguard the end users, which with the commercial launches of new 5G applications will no longer only be a mobile subscriber but a vertical sector. For the latter, requirements related to security and network integrity may be more stringent.

During the year 2022, BEREC shall organise an external workshop on Open RAN in order to explore further this topic including any benefits and risks related to cybersecurity, resilience and sustainability. Similarly, it will continue to explore how within its remit it can continue to contribute and liaise with stakeholders on issues related to sustainability and standardisation.

3 Creation of new wholesale markets / Neutral Host

The term 'neutral host' is often used to describe a (local) cellular network, providing wholesale mobile coverage solutions to mobile network operators (MNOs) and other service providers. With the arrival of 5G and 5G applications, MNOs need to continue searching for cost-efficient options to expand and densify their network. The network and services provided by neutral host have the potential to help MNOs improve network capacity in city centres, rural areas, inside buildings and along railways and other transport systems.

There are several types of neutral host emerging, ranging from pure passive model to spectrum-based model in which dedicated spectrum is used. Neutral network is expected to be capable of virtualization and can support different frequency bands of multiple MNOs. In case of a spectrum-based neutral host, the neutral host can accommodate other operators as tenants or roaming partners.

As shown in Figure 1, the deployment models for mobile network, the neutral host model (option (c)) is different to the traditional model (option (a) and (b)) in the way the network is deployed. Instead of MNOs building their own network, the neutral host model introduces intermediaries that offer wholesale access to MNOs¹⁵. The expectation is that, via this approach, MNOs can experience a significant cost reduction in both investment and maintenance.

¹⁵ "Enable 5G Neutral Hosts: 5GCity Architecture and Business Model", 5G City Source: https://www.5gcity.eu/wp-content/uploads/2020/05/WhitePaper_Enabling-5G-Neutral-Hosts-5GCity-Architecture-and-Business-Model-v1.0.pdf .

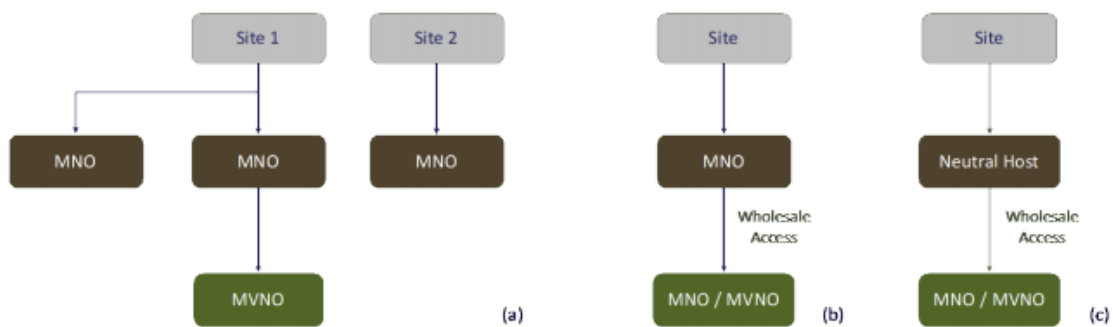


Figure 1: Deployment models for mobile network

Neutral host and indoor coverage

Indoor coverage is one of the topics that is often addressed with the neutral host model. In the classic deployment model, the MNO would most likely serve building inhabitants via outdoor network, sometimes complemented by femtocell or distributed antenna system (DAS) that is provided by the same MNO. This means that the same building is likely to be provided with several indoor systems and deployments in case the users in the building are subscribed to different service providers. The neutral host model instead aims to support multiple operators in a single radio access point while the MNOs have end-to-end performance control. This concept is expected to not only reduce deployment cost for each MNO but also resolve the propagation challenge of the high frequency bands that are required for 5G.

Neutral host and small cells

Small cells are expected to play an important role in network densification. One of the potential approaches in small cell deployment is to have a single network infrastructure that can be leased to any interested operators. In case the single network infrastructure is owned by a third party, the approach is considered as the neutral host model. The MNOs that are hosted may have different options to share this single network infrastructure, depending on the facilities and solutions provided by the neutral host.

Neutral host and spectrum

As most neutral host models expect a certain level of network sharing among the hosted MNOs (and possibly other hosted service providers), spectrum may become one of the relevant resources to be shared. In the situation where the neutral host doesn't own its own spectrum, spectrum sharing may become a possible option for the hosted parties (including the possibility that the neutral host is to manage the shared spectrum). In case the neutral

host has dedicated spectrum, the neutral host may be interested in offering RAN-as-a-Service¹⁶ to enhance and extend the traditional macro networks of MNOs.

Neutral host and edge computing

Edge computing plays a key role as the enabling technology to shorten the distance between users and services, in order to offer guaranteed low latencies and throughputs without network congestion in environments with an increasing number of connected devices, as required by the new 5G use cases oriented to localized areas, such as smart cities or industry 4.0. Edge computing implies moving content, services and signalling processing closer to customers by means of bringing compute resources closer to the devices. In this context, neutral host providers would have incentives to expand their portfolio and offer services to allow physical or virtual computing resources to be shared by multiple service providers, at locations where individual deployment is not an effective business case. In that way, neutral host model could provide edge computing capabilities to MNOs while offloading data traffic from their networks and reducing the backhauling costs.

Mr. Pujol, Cellnex Telecom, stated that the neutral host model is a pro-competition one, facilitating the necessary network densification using shared wireless infrastructure. Moreover, managed towers may help address the digital divide even by providing connectivity in the rural areas. Another benefit that the neutral host model promises is a more efficient use of resources resulting in more sustainable activity.

Regulatory considerations and BEREC's future work

BEREC recognizes the growing expectations in neutral host by the market. The intermediary role that the neutral host models are expected to introduce into the market may implicate a new wholesale market, especially when RAN and spectrum become part of the leasing options. This potential wholesale market is likely to create new dynamics in the value chain of mobile market, which as a result can impact competition.

At the same time, BEREC is aware that the adaptation of neutral host may limit infrastructure-based competition. In areas where mobile networks and services are already well served by for instance traditional macro networks, the shared infrastructure offered by neutral host can help accelerate the densification of network in an efficient and sustainable manner. The question is what this would mean for areas in which the neutral host would be the only 5G-infrastructure available. With this question in mind, BEREC will closely follow the development of neutral host and its impact on the mobile market.

¹⁶ See for instance the news release of Dense Air, <https://www.prnewswire.com/news-releases/dense-air-acquires-new-spectrum-to-build-neutral-host-shared-wireless-networks-in-australia-301345924.html>

4 Private/Local Networks

Establishing private/local networks allows the 5G verticals to have more control on their network, potentially with nimbler solutions that can be customized to specific use cases and able to address better security requirements. Both mobile operators and enterprises are active with regard to private/local networks, with cloud and hyperscale computing becoming much more active in this space as well.

Similar to other speakers, Mr. Bonifay, Transatel, stated that 5G will focus on the industrial market with applications relying amongst others on Internet of Things. Such applications will require public networks or private networks or both. However, the combination of public and private networks may be commonplace, with Mr. Bonifay identifying the automotive sector as one of those vertical sectors which will make use of both public and private networks, with the latter being deployed at factories to optimize manufacturing and at car dealers to optimize maintenance. Public networks will be needed for example for in-car entertainment with the ultimate application being autonomous driving. However, these applications will require various partnerships.

Dr. Pagano, COREALIS, described the private 5G network which was developed and deployed in Port of Livorno with the aim of developing a more cost-effective and environmentally sustainable operations model. A number of innovative services are provided on top of this private network including yard management, general cargo management, manoeuvring of vessels autonomously in port using an interconnection of IoT devices. Frequency bands have been provided by a local MNO. This consortium is another example how 5G will enable Business to Business (B2B) services, increase collaboration and also result in new wholesale models with the emergence of micro-operators.

During the workshop a number of speakers expressed their opinion on the assignment of spectrum for private networks. These diverging opinions highlighted some of the benefits and challenges related to setting aside spectrum for the vertical industries, or not. Regulators were urged by speakers to consider the pros and cons of making spectrum reservations. In the Port of Livorno frequency bands from a local MNO were used, providing coverage throughout the port. Dr. Pagano sees value in policy makers urging MNOs to make unused spectrum available to micro-operators or verticals for private network such as in the case of Port of Livorno where the Port Authority became a micro-operator. Moreover, this approach i.e. deploying an open architecture supported with decoupled infrastructure platform and service layers from the information stack and using dedicated spectrum acquired from an MNO would also facilitate switching between one MNO and another.

Panellists have referred to the differing regulatory conditions for network access within the European Member States; both in terms of infrastructure access and spectrum necessary for private networks. The differences between current solutions in Europe are perceived by the panellists as creating challenges for business opportunities, MVNOs and also smaller MNOs.

Regulatory considerations and BEREC's future work

BEREC recognises that certain verticals may rely on the deployment of private 5G networks in order to serve their needs best while also providing the necessary control and security. As discussed above, this may bring about new 5G business models especially with new players becoming micro-operators. Aligned with the three strategic priorities of BEREC i.e. promoting full connectivity, supporting sustainable and open digital markets and empowering end-users, BEREC will continue to engage with stakeholders on the emergence of new business models resulting from 5G to understand its impact on access regulation, security, protection of end-user and any other matters that fall within BEREC's competence.

In addition, BEREC recognises that the use of spectrum is an essential input into the operation of electronic communications networks and services and the development of innovative products and services. As a result, BEREC will continue to work closely with the Radio Spectrum Policy Group, including through the Peer Review process, so that there is a sharing of best practices between relevant experts including on the market shaping aspects of spectrum assignment.

5 Network slicing and 5G wholesale markets

A remark made by a number of panellists during the BEREC Workshop is that 5G, apart from providing new higher quality connectivity to the mobile subscriber, it aims to provide connectivity to the vertical industries catering specifically to their unique needs. More broadly, participants believe that even though 5G will bring improvements to mobile subscribers, it will mostly benefit the vertical industries. Moreover, the same vertical industry may need different key performance indicators (KPIs) for different services. An example of this was provided by Dr. Pagano, when he explained how certain services provisioned in the Port of Livorno use mMTC while others require uRLLC, within the same private network.

Serving different needs is also possible thanks to network slicing, allowing the provisioning of connectivity tailored to the vertical's needs i.e. high broadband, low latency, high reliability or high level of security or even a combination of the four over the same physical network. Network slicing deploys end-to-end logical networks on top of a shared physical network, so that it will meet the contracted service level agreements (SLA) with the verticals while resulting in efficient usage and management of the network resources to provide differentiated services at scale.

Network slicing was deployed in a number of 5G trials and pilots including 5GCroCo as explained during the BEREC Workshop on 5G by Dr. Hetzer. In the case of 5GCroCo, network slicing was needed for the provision of three different use cases¹⁷ related to the automotive industry within national and cross-border geographical regions resulting in providing three different services over a scenario involving cross-border; cross-MNO; cross-car-OEM and

¹⁷ Use Case 1: Tele-operated Driving; Use Case 2: High Definition Map Generation and Distribution for Autonomous Driving; Use Case 3: Anticipated Cooperative Collision Avoidance

cross-telco-vendor. It is clear that network slicing and QoS go hand in hand in 5G networks, evidenced with for example the use of End-to-End QoS with network slicing in 5GCroco.

Cross-border interoperability is also one of the main points to take into consideration. Dr. Hetzer, 5GCroCo, which trials 5G technologies in the cross-border corridor along France-German and Germany-Luxembourg, highlights that it will be necessary for telecom parties to work together to ensure smooth cross border functionality even if this involves roaming from an operator's network slice to another operator's network slice¹⁸. Moreover, one of the key technical needs for the automotive sector is to ensure QoS in a cross-border corridor; which in the case of 5GCroCo is achieved with the help of predictive QoS¹⁹, Mobile Edge Computing, Network Slicing, new Radio Capabilities and MNO Handover. This could foster more opportunities for wholesale services.

Regulatory considerations and BEREC's future work

BEREC recognises that network slicing provides operators new ways to reach new customers i.e. to serve the 5G verticals, as it can provide differentiated performances over the same physical infrastructure. These new business models could enable new interplay between infrastructure providers, mobile (virtual) network operators and could also allow new players to enter the market, as intermediaries or top-level service providers for specific industry, or for local connectivity.

BEREC recognises the wholesale market will look different with 5G, because new technical possibilities will allow for new B2B and wholesale services, and the network density and national and cross-border interoperability required necessitate operators to work together.

BEREC also recognises that by broadening the range of services made possible by 5G, there could be an issue of cross-border interoperability and roaming across countries, especially for services based on mobility that use network slicing. As a result, BEREC will continue to engage with stakeholders to identify what, if any, barriers to trans-national connectivity could arise so that appropriate solutions can be supported.

¹⁸ "In order for NSP to ensure that the service requirements for the service are met while roaming, a roaming agreement to support network slicing between NSP A and NSP B must be in place that covers the related network functionality and required services" where NSP is a Network Slice Provider. Source: <https://www.gsma.com/newsroom/wp-content/uploads/NG.116-v4.0-2.pdf>

¹⁹ "Predictive Quality of Service (pQoS) can be used to adapt the behaviour of the tele-operated driving functions to accommodate for a decreased QoS. For example, the compression of video data can be increased when the predicted capacity of the uplink is insufficient to transmit the regular video quality. A further example is a dynamically adapted maximum vehicle speed based on the predicted network latencies." Source: https://5gcroco.eu/images/templates/rsvario/images/5GCroCo_D2_2_v2.pdf

6 Anticipated Pace of Innovation

A common sentiment that has been re-iterated in both panel discussions of this BEREC Workshop is the focus that has been given during the development of 5G, on how to best serve the 5G verticals using this new cellular technology, 5G. Dr. Willcock, 5G IA stated that what differentiates 5G from previous generations is the ability to digitize other industries beyond telecoms. However, different sectors have gained different levels of maturity in terms of the adoption of 5G use cases, with some near market such as the automotive sector or manufacturing but others are still 5 to 10 years from commercial launch. Prof. Bernardos Cano, 5Growth, also anticipates that Industry 4.0 will be one of the first verticals to adopt 5G commercially. 5G in Manufacturing and Industrial Automation has garnered a lot of attention and was also referenced to as an example by a number of panellists discussing 5G ecosystem diversifications including Mr. Wreschner, Vodafone, and Mr. Bonifay, Transatel.

Mr. Neira Rey, AXON Partners Group predicts a staged approach to the adoption of commercial applications of 5G. With the first stage taking place within the next one to two years, in which 5G will impact existing industries and business models by enhancing current operations and services. The examples provided include Fixed Wireless Access and Smart City applications. In the following three years, one expects to see the uptake of more advanced 5G applications which rely further on the 5G's enhanced capabilities. Examples of such applications include collaborative gaming and interactive live events. In the last stage – the full realisation of 5G – will result in the commercial launches of much more complex applications such as remote surgery or potentially highly autonomous vehicles. Mr. Neira Rey stated that this last stage is expected in 5 years' time.

Dr. Willcock mentioned that the vertical industries are often times larger than the telecom sectors and have their own standardization. Prof. Bernardos Cano from 5Growth also re-iterated a similar message on the ability to provide the solution to the verticals in the way they want it and they need it. This ties to the message by Mr. Budník, Thein, who stated that his approach is technology neutral as the most important thing is to deliver the needs requested by the client. Prof. Bernardos Cano, 5Growth, mentioned that the key parameters in terms of QoS that must be delivered by a 5G network in order to enable real-life implementation of the use cases considered in 5Growth i.e. Industry 4.0; Transportation specifically Rail; and Energy are high reliability for critical applications, low latency and bandwidth for industrial processes, automotive and augmented reality (AR).

Trust has been identified by Dr. Willcock as a critical factor in the market of 5G by the 5G verticals. It is imperative that the 5G verticals trust that the technology delivers what they need. A number of new use cases, such as automated mobility and remote management of a factory plant, necessitate higher levels of integrity. Thus, treating 5G as a critical national infrastructure will be important, not only to fulfil the verticals' needs but also because failure to deliver the KPIs necessary for the 5G use cases can result in causing physical harm to humans. Mr. Budník, Thein, stated that cyber-security is a topic that is of increasing relevance, becoming the main target for the future. Mr. Summer, Ericsson, discussed how security plays a critical role for next generation communications: there are different needs regarding

performance and security. Different technology choices will result in different levels of security.

Dr. Hetzer, presented the 5GCroco's work on three applications which can have a critical impact on the safety of life of citizens. These focus on autonomous driving particularly, Tele-Operated Driving, High Definition Map Generation and Distribution of Autonomous Driving and Anticipated Cooperative Collision Avoidance. A building block for these use cases is ensuring QoS, with 5GCroCo using predictive QoS. Moreover, it relies on distributed computing enabled by Mobile Edge Computing, End-to-End QoS with Network Slicing and Precision Position supported by mobile networks.

Regulatory considerations and BEREC's future work

One of the strategic objectives of BEREC for the period 2021-2025 is empowering end-users. BEREC acknowledges that with the uptake of pure 5G use cases, the end user will no longer be a mobile subscriber only but it can be a factory plant or an autonomous vehicle or vessel. BEREC will continue to examine regulatory elements which fall within its remit that may impact end-users irrespective of whether the end-user is a mobile subscriber or a 5G vertical. BEREC acknowledges that QoS, networks' integrity and security continue to be paramount and the recommendation made to treat 5G networks as a critical national infrastructure.

As more use cases transform into business cases, and as more stakeholders work out their connectivity needs, BEREC expects there to be an uptake of network slicing. In relation to the information needs for verticals, BEREC already started looking into this topic in 2020 but concluded that it was too early to provide information to verticals on coverage.²⁰ Moreover, during another BEREC workshop in 2021, stakeholders informed BEREC that new connectivity solutions will be agreed at the B2B level without the need for any regulatory intervention by BEREC or NRAs.²¹

Mobile Edge Computing and Private networks supported by 5G will enable other types of new services and networks. As a result, there will likely be further opportunities for BEREC to deliver on the strategic objective on the promotion of full connectivity. In this regard, BEREC notes the emergence of the 5GZorro marketplace as an example of the innovative solutions that 5G and emerging technologies can bring.²²

²⁰ BoR(20) 33 https://bereg.europa.eu/eng/document_register/subject_matter/bereg/reports/9030-feasibility-study-on-development-of-coverage-information-for-5g-deployments

²¹ BoR(21) 163 BEREC summary report on workshop on NRA experiences with 5G, see section 5: Beyond the eMBB use case

²² see section 2.0 above on New Business opportunities

Annex I

	Description	Trend
New business opportunities	5G has the potential to impact existing value chains.	5G technical developments and the increasing role of 5G across a range of industries have the potential to impact existing value chains and result in new business models beyond connectivity. They may influence both wholesale buyer and retail end-user choices in terms of providers (MNO, MVNO, WISP, other micro operators e.g. using a network slice) and / or fixed network operators.
Creation of new wholesale markets	5G could allow for new players to enter the market.	Industry automation use cases potentially increase the need for tailor-made 5G services by new micro-operators (plant wide operators, campus operators), thus creating new business models such as e.g. intermediaries that could provide wholesale access, bundle or repackage solutions for the specific industry or specific local sites with the necessary network operator.
Private/local networks	Introduction of private/local networks.	Many see an increase in revenue streams for operators to arise from the business-to-business segment where private/local networks will play an important role for certain verticals/sectors. Enhanced 5G features such as URLLC and network slicing could be applied to Private/Local networks.
Network slicing and 5G wholesale markets	Higher QoS-requirements might be implemented using 5G network slices	Industry automation and other use cases (e-health, gaming...) with specific URLLC and bandwidth needs may increase the need to be able to differentiate services with different classes of quality of services which might be supported by the use of network slicing beyond other technical solutions. These use cases will have to follow Net Neutrality regulation.