Qualcomm Europe Inc.

CONSULTA PÚBLICA SOBRE EL PLAN NACIONAL DE 5G

Qualcomm Response

Qualcomm is pleased to provide Ministerio de Energia, Turismo y Agenda Digital on the 5G National Plan.

An EU Commission study[1] forecasting the socio-economic benefits of 5G, estimates that in 2025 benefits from the introduction of 5G capabilities could reach €113.1 billion per year in four key sectors that will also be using 5G connectivity: automotive, health, transport and energy. Investments of approximately €56.6 billion will be likely to create 2.3 million jobs in Europe. The European Commission has identified early introduction of 5G as being a key priority for Europe's communication industries.

Qualcomm recommends the following:

- Release first 200 MHz of spectrum in the 3.6 - 3.8 GHz band and 1 GHz of spectrum in the 26.5 – 27.5 GHz no later than 2018 so **that 5G commercial services utilizing these bands could start by 2019.**
- Design an auction enabling operators to deploy 5G over large contiguous spectrum of at least 100 MHz per operator in the 3.4 – 3.8 GHz range and 400MHz per operator in the 26.5 – 27.5 GHz range.
- Adopt award procedures and licensing approaches designed to maximize the investment in networks and providing certainty in availability of spectrum for 5G to

[1] *"Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe" (SMART 2014/0008)*

MNOs, enabling a stable network investment environment aimed at providing predicable network performance for a diverse range of 5G use cases

- Release the 1400 MHz band selecting an award procedure enabling as potential outcome the deployment of at least 2 networks of 20 MHz (1452 – 1492 MHz) and accelerate the refarming of whole 1427-1517 MHz band.
- To focus 5G trials initiatives on MBB use case for initial deployments before 2020 using the priority bands identified by the European Commission in its action plan (700MHz, 3.4 – 3.8 GHz and 26 GHz). Such trials could start as soon as in 2017. It would be important that such potential trials would not delay the release of spectrum and the deployment of 5G in the country but on the contrary should be used to accelerate its release and pave the way to a faster deployment.
- Review the applicable exposure limits, taking into account the work and recommendation of ICNIRP

Question 2 *Neutralidad de red Recientemente se ha aprobado en el ámbito europeo una regulación sobre neutralidad de red, ¿Considera que dicha regulación puede afectar a la provisión de los servicios 5G? ¿Debería adoptase alguna medida regulatoria específica en este ámbito?*

The benefits of 5G are linked to the ability for operators to differentiate traffic in order to deliver the right QoS for the right traffic.

It is critical to review Net Neutrality rules and regulations in the context of 5G, in particular to enable managed services. While Qualcomm fully supports net neutrality for internet access, Qualcomm also strongly believe that differentiated QoS should be available for managed services.

Joint work with all actors to qualify managed services (as opposed to internet access) could also provide better certainty to actors for the deployment of innovative services.

Question 5

Evolución de la normalización técnica ¿Cuál es su previsión en relación con la volución de la normalización técnica de 5G y el calendario estimado? ¿Considera que el desarrollo de las normas técnicas es el adecuado para facilitar el despliegue de las

redes y servicios 5G en Europa? ¿Existe alguna otra norma técnica, además de los señalados, que convendría tener en cuenta?

EC/CEPT

The European Commission has identified early introduction of 5G as being a key priority for Europe's communication industries. In 2016, it published its action plan that targets a Gigabit Society with the start of 5G trials from 2017, the launch of early 5G networks by 2018 followed by commercial 5G services in at least one major city in each Member State by 2020 and full 5G deployment across the EU by 2025. Pioneer spectrum bands have also been identified as part of this initiative in the three ranges of the spectrum: below 1 GHz (700MHz), between 1 GHz and 6 GHz (3.4 – 3.8 GHz), and above 6 GHz (26 GHz). European regulatory bodies are working fast on harmonizing the 3.4 - 3.8 GHz and 26 GHz ranges and most recently also the extended L band (1427 -1517 MHz) for 5G. The overall goal is to provide a regulatory framework to incentivize operator investments for consistent Gigabit services, introducing appropriate regulatory measures. In particular, in CEPT, ECC PT1 has been tasked to develop an ECC Decision on harmonized technical conditions for MFCN in 24.25-27.5 GHz taking into account 5G requirements by June 2018 (ahead of WRC-19). ECC PT1 is also working on the existing ECC DEC 11(06) to make it fit for 5G by June 2018 and on a number of recommendations for Member States to reduce fragmentation in the 3.4 – 3.8 GHz band. Qualcomm believe that the expected timeline of completion of both harmonization decisions will enable Spain and Member States in Europe to award spectrum in 2017/2018 timeframe and pave the way for 5G deployments as early as in 2019.

3GPP standardization activities and acceleration

At its March plenary meeting, 3GPP agreed to a work plan proposal (RP-170741) for the first 3GPP 5G New Radio (NR) specification that will be part of Release 15 – the global 5G standard. As part of this work plan, Qualcomm and other mobile industry leaders committed to accelerate the 5G NR schedule by introducing an intermediate milestone for an early completion of a variant called Non-Standalone (NSA) 5G NR. This intermediate milestone will enable 3GPP-based large-scale trials and deployments as early as 2019.

The previous project plan for 5G NR (as part of 3GPP Release 15) was allowing standard-compliant 5G NR deployment around 2020. With the agreed-to proposal, there will be an earlier intermediate milestone to complete technical specifications related to a configuration called Non-Standalone 5G NR in such a way to enable large-scale trials and deployments starting in 2019.

- Non-Standalone (NSA) 5G NR will utilize the existing LTE radio and core network as an anchor for mobility management and coverage while adding a new 5G carrier. This is the configuration that will be the target of early 2019 deployments (in 3GPP terminology, this is NSA 5G NR deployment scenario Option 3).
- Standalone (SA) 5G NR implies full user and control plane capability for 5G NR, utilizing the new 5G core network architecture also being done in 3GPP.

With the recently agreed upon proposal, it is defined a framework to ensure commonality between these two variants, as well as making forward compatibility a key design principle for the standardization of the first release of 5G NR. This will enable in-band introduction of new capabilities and features in subsequent releases of the standard, such as the addition of new signals to support new industries or use cases to achieve the 5G vision to connect everything to everything. An overview of the 3GPP 5G NR Release 15 work plan and schedule can be seen below; the complete details can be found in RP-170741.

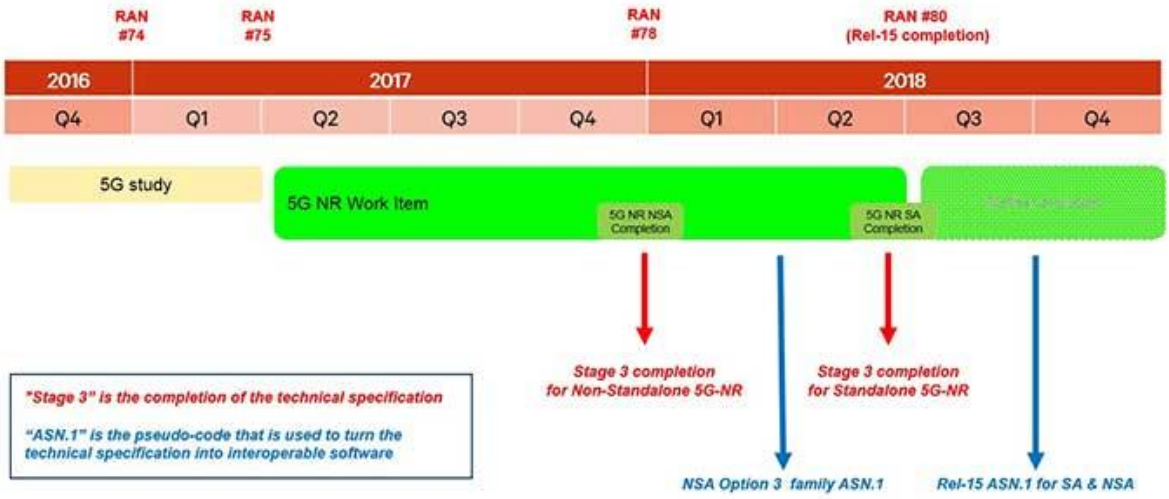


Figure 1: 3GPP work plan for 5G NR Release 15

5G NR deployments in 2019 will require more than just R&D test beds and a 3GPP specification. For example, it will require over-the-air trials and interoperability testing, compliant with the 3GPP 5G NR specification, to test and simulate 5G NR technologies in real-world scenarios across a broad set of use cases and deployment scenarios. In addition, an accelerated timeline for 5G NR deployments would be incomplete without supporting devices. This is why Qualcomm recently announced the expansion of our Qualcomm Snapdragon X50 5G modem family to include new multi-mode 2G/3G/4G/5G modems that will support the global 5G NR standard – both sub-6 GHz and multi-band mmWave – and Gigabit LTE on a single chip. Please find attached the following whitepaper:

- qualcomm-snapdragon-x50-5g-modem-infographic

Other regulations

Qualcomm would like to point out that emission limits currently defined by the ORNI are set much lower than the recommendation from the ICNIRP. The GSMA published a document highlighting that such limits already led to deployment restrictions on 4G networks. Deployment of additional bands will obviously be even more problematic if such limits are maintained, as current site will not be able to radiate more power. This could put severe restrictions on the deployment of 5G networks. ICNIRP is also working on the revision of its recommendation.

Qualcomm recommends Spain to get involved in the work of ICNIRP and to align and harmonise as much as possible the values with the recommendations from ICNIRP.

To sum up, Qualcomm believe that current standardization activities in 3GPP and regulatory bodies are on the right track to enable deployments of 5G networks and services in the 3.4 – 3.8 GHz and 26 GHz as early as in 2019.

Question 6

Despliegue de las redes y normalización técnica ¿Cómo estima que va a influir en el despliegue de las redes la evolución de la normalización técnica? ¿Considera que es adecuado iniciar despliegues sin que se haya completado la normalización? ¿Cuánto tiempo después de la disponibilidad de estándares podrían estar disponibles los primeros equipos y terminales?

As stated in the previous answer Qualcomm believe that current standardization activities in 3GPP and regulatory bodies are on the right track to enable deployments of 5G networks and services in the 3.4 – 3.8 GHz and 26 GHz as early as in 2019. In particular, 5G deployments in the mmWave 26.5 – 27.5 GHz could benefit from equipment availability in other regions of the world

Question 8

Despliegue de escenarios ¿En qué fecha cree probable que se desplieguen cada uno de los escenarios? ¿Será necesario el despliegue de todos los escenarios en 2020?

The first 5G deployments will definitely target eMBB (enhanced Mobile Broadband) use cases. In fact, eMBB will create enormous business opportunities for operators, by allowing them to provide larger data plans (potentially unlimited data plans) and new services, in particular mobile video streaming. This could bring forward a new phase in the mobilization of the Internet. In fact, most of the Internet traffic today is made of video streaming.

We envision that other use cases will follow after initial 5G launches in 2019/2020. In particular, Massive MTC (Machine-Type Communication) will be a continuation of the ongoing deployment of Cellular MTC (CAT-M1 and NB-IOT). Notice that these technologies continue to evolve and improve today within the Rel-15 LTE standardization effort. Rel-15 is

supposed to introduce further improvements over the initial introduction of these technologies in Rel-13 and Rel-14. While these improvements will address some 5G requirements and will be deployed likely at the same time as 5G (2019/2020), the complete vision of Massive MTC will be developed within the 5G framework in the next Rel-16. Hence, 5G MTC will be deployed at a later stage.

Ultra-Reliable Low-Latency Communication (URLLC) will also be deployed likely later than eMBB. Notice that some components of URLLC will already be available and deployed with initial 5G launches, though. One prominent example are the low-latency features associated to 5G NR (e.g., self-contained sub-frame). In fact, these feature would also benefit other use cases such as AR/VR.

Question 10

Coexistencia entre las redes existentes 4G y la tecnología 5G ¿Considera que las redes 4G y sus evoluciones podrán proporcionar los
requisitos necesarios para algunos de los servicios previstos (IoT, vehículo conectado y la gestión inteligente de servicios e infraestructuras, servicios
de vídeo del futuro)? ¿Cómo considera que se producirá la coexistencia y transición entre las tecnologías móviles actuales y la nueva tecnología 5G?
¿considera que a partir de 2020 existirán redes 4G y 5G completamente independientes, o se mantendrá la dependencia del 5G como complemento
al 4G? ¿En qué momento estima que la red 5G será independiente de la 4G?

As stated before, some technologies (CV2X, CIOT, MTC) continue to evolve and improve today within the Rel-15 LTE standardization effort. However, the complete vision of Massive MTC and ITS (Intelligent Transportation Systems) will be developed only within the 5G framework in the next Rel-16. So, it is envisioned that at a certain point the more advanced instances of these services will naturally fall within the 5G framework. However, legacy service and devices will continue to connect via the 4G network, which is expected to remain operative way beyond 2020.

In 2020 MBB services will make use of both 4G and 5G networks. In fact, initial deployments will be configured according to the NSA (Non-Stand-Alone) system architecture, whereby the 4G network is used for control traffic (e.g., mobility management) and also data traffic,

together with the 5G network. The aggregation of 4G and 5G capabilities will provide a tremendous throughput boost for MBB services, which will be unprecedented and impossible to reach with 4G alone. Furthermore, the NSA architecture will allow operators to deploy 5G in areas ("hotspots") where their networks are particularly suffering from lack of capacity or where they intend to strategically offer new services.

The NSA configuration is expected to be replaced fairly rapidly by a full-fledged SA (Stand-Alone) 5G deployment. The timeline of this transition will depend on multiple factors. First of all, it will depend on the capillarity of 5G equipment deployment across the sites of each operator, i.e., on the progressive coverage of 5G services. In fact, 5G will be able to fully detach from 4G only when the service will reach a sufficient geographical footprint, beyond hotspots. In a second stance, it will also depend on the availability of more 5G spectrum to aggregate, but also on the refarming of existing 3G (and later 4G) bands. As more spectrum will become available (either through new auctions or refarming of existing bands), the capaibilities of 5G networks will proportionally grow, making the addition of 4G fairly immaterial to provide the desired level of service in terms of throughput and capacity.

Question 11

Despliegue de small cells ¿Cómo prevé que se logrará la necesaria capilaridad de las redes 5G en el acceso? ¿Cómo se realizarán los despliegues de small cells de baja potencia en entornos rurales, sub-urbanos y en áreas de alta densidad de población? ¿En qué año considera que el despliegue 5G deberá ser generalizado, al menos, en áreas urbanas?

This question is related to the previous one, as 5G networks are expected to become independent of the 4G networks whenever their deployment will be sufficient to guarantee service coverage in a given scenario.

It is crucial to highlight how 5G comes with technologies as Massive MIMO that would allow to greatly increase the coverage of 5G sub6 (e.g., 3.6GHz) bands. These solutions will enable deployment of 5G NR sub6 in existing LTE urban macro sites (whose density is typically driven by coverage at 1800-2100MHz). As far as rural areas, 5G might initially make use of sub-1GHz low-bands like 800MHz. These bands will have exactly the same coverage as LTE low bands (hence they could reuse the same macro sites), even though the service offered

might not differentiate much with respect to 4G in terms of throughtput and capacity (it will in terms of latency). In general, 5G sub6 bands are supposed to reuse existing macro sites, both in rural and in urban environments. Hence, achieving widespread coverage with 5G sub6 is expected to be a rather quick process.

On the other hand, 5G mmW (26GHz) bands will surely have reduced coverage as compared to existing LTE macro sites. Hence, 5G mmW will likely require to be deployed on small cells. However, small cells are not being introduced with 5G. LTE has already introduced several features supporting small cells and Heterogeneous Networks (HetNets) as early as Rel-8 (eICIC, feICIC, LTE-U, LAA, eLAA). Several operators around the globe (particularly in the US) are currently deploying small cells to address hotspots coverage and to enable aggressive data plans. This means that, if LTE evolution proceeds at a steady pace before 2020, operators might already be prepared for the deployment of mmW on an existing small cell infrastructure. The continual evolution of LTE is in this sense a necessary preparation for the advent of 5G.

Question 15

Servicios previstos en las diferentes bandas de frecuencia ¿Qué escenarios (Banda ancha mejorada, Comunicaciones ultra fiables y de baja latencia y Comunicaciones masivas tipo máquina) y servicios considera que serán los que se ofrezcan en cada una de las bandas? ¿Considera que las bandas enumeradas deben dedicarse al 5G o pueden utilizarse para otras tecnologías? ¿Existen otras bandas que puedan utilizarse para prestar servicios 5G, ya sean las actuales bandas dedicadas a los servicios de comunicaciones electrónicas, u otras nuevas?

5G will be a unified design, scalable and adaptable across extreme variations in requirements to address a variety of use cases across all spectrum bands and types (licensed, shared and unlicensed) from below 1 GHz (e.g 700 MHz) for wide area coverage deployments to higher bands up to 6 GHz (e.g. 3.4 – 3.8 GHz) for more capacity focused deployments, to above 6 GHz and mm Wave (e.g 26 GHz) for extreme bandwidth and more targeted capacity deployments. Bands already harmonized below 1 GHz, including particularly the 700 MHz band, are important for 5G in order to enable nationwide and indoor 5G coverage. The importance of the 700 MHz band is not only due to its large

coverage benefits, but also to the role it is expected to play for the future of 5G in Europe as 5G is expected to deliver not just improved mobile broadband, but critically a technology platform for the emergence of so-called verticals. 5G technology will enable verticals such as M2M/IoT and broadcasting to benefit from performance and economies of scale that can only be delivered by the mobile ecosystem. The 3400-3800 MHz frequency range offers an optimal balance between coverage and capacity, which will support a broad range of 5G applications, including: Augmented Reality/Virtual Reality (AR/VR), Ultra High Definition (UHD) video, smart home, smart manufacturing, health care and drones. The 3400-3800 MHz band will also provide both mobile connectivity "on the go" and Fixed Wireless Access (FWA) for domestic and business applications. 5G will also open up new mmWave opportunities for mobile broadband. The abundant spectrum available at these high frequencies is capable of delivering extreme data speeds and capacity that will reshape the mobile experience (please see attached whitepapers). In addition to the pioneering bands identified by the RSPG, provided that technical and regulatory conditions are made fit for 5G use, all bands already harmonized for mobile networks could be in the medium / longer term of interest to deploy 5G. In addition to those, it is worth highlighting that the 3.8 – 4.2 GHz could be an important and useful extension to the 3.4 – 3.8 GHz range. In the longer run, the 40.5-43.5 GHz band, not extensively used by incumbents in Europe, could also provide large additional 5G capacity in subsequent upgrade steps to 5G networks as more and more services will be put onto these networks.

Please find attached the following whitepapers:

- augmented-and-virtual-reality-the-first-wave-of-5g-killer-apps
- whitepaper-making-5g-nr-a-reality

Question 16

Organización de las bandas de frecuencia Con el fin de garantizar la provisión de servicios 5G con calidad suficiente, ¿cuál sería la distribución idónea en bloques de frecuencia par cada una de las bandas? ¿Es necesario que los operadores dispongan de frecuencias en los distintos tipos de bandas? ¿Cuál debería ser el modelo de despliegue y de cobertura mínima en los distintos escenarios para la provisión de servicios?

Please see answers to questions 18/19/20/21 concerning the 700MHz, 1427 – 1517 MHz, 3.4 – 3.8 GHz and 26 GHz. As stated in the answer to the previous question, 5G will be scalable and adaptable across extreme variations in requirements to address a number of different use cases requiring different kind of spectrum in low, mid and high bands. Thus Qualcomm recommends that MNOs have the possibility to use spectrum in the 3 different ranges and in particular in those RSPG recommended pioneering bands (700 MHz, 3.4 – 3.8 GHz and 26 GHz) for first deployments before 2020.

Question 17

Modelo regulatorio para licitar y utilizar las bandas de frecuencia ¿Cuál debería ser el modelo de licenciamiento (concesión, autorización general,…) y tipo de uso (uso privativo, autoprestación,…) para las diferentes bandas? ¿Cuál sería el ámbito geográfico en cada caso?

Please see answers to 18/19/20/21 concerning the 700MHz, 1427 – 1517 MHz, 3.4 – 3.8 GHz and 26 GHz.

Question 18

Organización y licitación de la banda de frecuencias 3,4-3,8 GHz ¿Cuál considera que sería la distribución en bloques de frecuencia más eficiente teniendo en cuenta la situación existente en España? En particular, ¿debería reorganizarse la banda o, manteniendo la situación actual, licitarse únicamente la subbanda 3,6-3,8 GHz? ¿Cuándo considera que sería el momento más adecuado para realizar la reordenación y/o licitación? ¿Cuál sería el modelo de licitación más adecuado: concurso o subasta? ¿Cuál sería el ámbito geográfico idóneo de las concesiones a licitar? ¿Considera conveniente incluir algún tipo de obligación (cobertura, compromisos de inversión,…) asociada a la licitación?

Availability of spectrum is a key requirement to enable development, testing and early deployment of 5G before 2020 and we do believe that the 3400-3800 MHz will be the primary band in the spectrum between 1 GHz and 6 GHz for the introduction of 5G in Europe before 2020. The proximity of this band to existing bands used for mobile, the potential reuse of existing infrastructure in areas where dense networks are deployed, bandwidths considerably wider (in the order of 100 of MHz) than those of today that can assist to

address 5G use cases in the short/medium term providing a combination of capacity and coverage making the 3400 – 3800 MHz range very attractive for 5G.

Qualcomm believe that establishing a 5G spectrum roadmap in Spain with a clear firm timeline is indispensable to give proper guidance to industry, to encourage and attract early deployment of 5G systems in the country and to create a less uncertain environment encouraging national and foreign investments.

In particular, given the situation in the country, Qualcomm believe that it is critical for Spain to release first 200 MHz of spectrum in the 3.6 - 3.8 GHz band in 2018. Furthermore, considering the importance to ensure that each operator could have access to wide contiguous spectrum assignments in the order of 100MHz to reap the full benefits of this frequency range for 5G (please see Appendix I), it would be important for the Ministry to work with current license holders in the band 3.4 – 3.6 GHz so that a solution could be found and a roadmap with clear timelines established to enable operators to deploy 5G also in this frequency range.

Last but not least, Qualcomm believe that Spain should auction the band in conformity with the revised ECC DEC 11(06) as soon as this is made available (target completion date is June 2018).

Question 19

Organización y licitación de la banda de frecuencias de 26 GHz ¿Cuál considera que sería la distribución en bloques de frecuencias más eficiente teniendo en cuenta la situación existente en España? ¿Considera que hay en la actualidad suficiente espectro disponible en esta banda? ¿Cuál es la cantidad mínima de espectro contiguo que debería disponer un operador? ¿Cuándo considera que esta banda debería estar disponible para el 5G? ¿Cuáles serían los modelos de autorización más adecuados para la puesta a disposición del sector de esta banda?

5G NR is being designed to get the most out of every bit of spectrum across a wide array of spectrum regulatory paradigms (including licensed, shared, and unlicensed) and all spectrum

bands – from low bands below 1 GHz, to mid-bands from 1 GHz to 6 GHz, to high bands above 24 GHz known as millimetre wave (mmWave) which will open up vast amount of bandwidths for extreme data rates and capacity that were previously not usable for wide-area mobile communications.

Qualcomm has been at the forefront of mmWave technologies. Having commercialized 802.11ad 60 GHz chipsets for mobile devices, Qualcomm is also developing and testing early mmWave prototype that operates at 28 GHz band today but also scalable to other frequencies. Qualcomm has also recently announced its first 5G mmWave modem, the Snapdragon X50, which will become available starting in second half of 2017 to enable early 5G mmWave trials and commercial fixed wireless deployments. The learning from taking on the challenge of integrating new mmWave technology into commercial devices and networks will help to accelerate the finalization of the 5G NR standard and usher in 5G NR networks and devices.

Amongst other initiatives, recently Qualcomm, Ericsson and AT&T announced collaboration on 5G NR trials intended to accelerate wide scale 5G deployments. The trials will support operation in mmWave spectrum, aiming to accelerate commercial deployments in the 28GHz and 39GHz bands.

Identification of mmWave bands for 5G is ongoing around the world:

- United States (US): the Federal Communications Commission (FCC) is driving key spectrum initiatives to enable 5G across low, mid, and high bands. In the high-band, about 11 GHz of spectrum (28 GHz, 37-40 GHz, and 64-71 GHz) has been made available for mmWave applications, with additional candidate bands identified for IMT-2020.
- China: the initial focus is on sub-6 GHz spectrum bands, with approved trials in 3.4-3.6 GHz, but there are also activities in identifying mmWave bands, initially 24.25-27.5 GHz, and longer term targeting 27.5- 29.5 GHz as well – public consultation in China is currently ongoing regarding the 24.25 -27.5 GHz and 37 – 42.5 GHz bands.
- South Korea: early 5G is planned for the higher mmWave bands, focusing on 28 GHz (similar to the 28 GHz band in the US and Japan). This is driven by the combined KT-SIG/VZ-5GTF effort, targeting trials at the 2018 Winter Games, with the possibility to

use the same band for early 5G deployments afterwards. In addition to 28 GHz, Korea is also looking at opening 37.5-40 GHz.

- Japan: there is a strong focus on both sub-6 GHz and mmWave bands, including 3.6-4.2 GHz, 4.4-4.9 GHz, and 27.5 GHz-29.5 GHz.

In Europe:

- In November 2016, The Radio Spectrum Policy Group (RSPG) recommended the 24.25-27.5 GHz as a pioneer band for 5G above 24 GHz.
- In December 2016, the EC RSCOM (Radio Spectrum Committee) issued a mandate to CEPT to study and assess the 24.25-27.5 GHz ('26 GHz') frequency band as a 5G pioneer band for use under relevant 5G usage scenarios and to develop channeling arrangements and common and minimal (least restrictive) technical conditions for spectrum use in the 26 GHz frequency band, which are suitable for 5G terrestrial wireless systems, in conjunction with relevant usage and sharing scenarios.
- In CEPT, ECC PT1 has been tasked to develop an ECC Decision on harmonized technical conditions for MFCN in 24.25-27.5 GHz taking into account 5G requirements by June 2018.

In the Member States:

- In the UK the Government (DCMS and HM treasury) has published its 5G strategy in March 2017
- OFCOM have initiated a work program on 26 GHz band availability for early 5G deployment - OFCOM is expected to release the 26.5 – 27.5 GHz part of the 26 GHz band in a first phase – band is currently managed by MoD but agreement between MoD and DCMS was achieved to release the band
- BNetzA is consulting on a potential award of spectrum in the 26 GHz band and 28 GHz bands – auction is expected in 2018 timeframe
- ARCEP spectrum consultation included 26 GHz – upper part of the band with the 26.5 – 27.5 GHz expected to be released first
- Sweden PTS is looking at "large-scale 5G tests" in 26 GHz and decided to make available up to 1 GHz (26.5 – 27.5 GHz) for it in 2017 for trials – release expected in 2019

- Finland is looking at "large-scale 5G tests" in 26 GHz, decided to make available up to 1 GHz (26.5 – 27.5 GHz) for it in 2017 for trials – expected release in 2019

In this context and considering the country situation, Qualcomm welcome Spain initiative to start considering the release of mmWave spectrum bands that could be used for 5G. Identifying and communicating to the industry as early as possible availability of spectrum above 24 GHz would allow the industry to have sufficient time to develop and make available enabling technologies serving trials and initial rollouts.

In particular, Qualcomm believe that:

- The 26 GHz band should be made available for 5G in line with EU, RSPG and CEPT plans
- Harmonized technical conditions in CEPT making should make sure that they facilitate 5G deployments and that realistic assumptions about 5G (5D parameters and IMT.Model) and incumbents (e.g. FSS I/N) are developed and excessive constraints on 5G deployments are avoided.
- It will be important to take into account the equipment availability in other regions of the world and the overlap between the Korean/US bands (28 GHz) and the European 26 GHz band and ensure that conditions are aligned at the 27.5 GHz boundary so that global economies of scale can be realized.
- **Spain should release in the 2018 timeframe, immediately after CEPT finalizes the harmonization decision concerning the 26 GHz band, the upper 1 GHz of spectrum (26.5 – 27.5 GHz) so that 5G commercial services utilizing this band could start by 2019.**

Furthermore considering that 5G is a new technology and a new market which requires global scale to gain market lift off during the launch phase, mobile operators play a key role in order to help generate a competitive equipment market. Thus mobile operators' role in the commercial deployments in the mmWave spectrum is critical.

In particular, Qualcomm believe that:

- Licensing approach for 5G in the 26.5 – 27.5 GHz band should provide certainty in availability of spectrum for 5G, and enable a stable network investment

environment aimed at providing predicable network performance for a diverse range of 5G use cases.

- Complex sharing mechanisms should be avoided where simpler mechanisms are possible, and licence conditions should allow for a flexible network rollout based on market/operator needs (e.g. 26GHz coverage obligations are unlikely to be beneficial from an investment perspective)
- Although 5G will be using both licensed and unlicensed spectrum, Qualcomm preference for the 26.5 – 27.5 GHz band would be to be awarded on a **licensed** or licensed shared basis.
- Since the basis of demand for 5G spectrum in 26GHz is likely to be to provide highly predicable network performance for MBB and other ultra-reliable, low latency use cases, certainty over the amount of spectrum available at different locations is key. Thus, Qualcomm recommend to avoid sharing mechanisms using DSA techniques.
- MNO spectrum needs in 5G are likely to become more diverse (i.e. more diversity in business cases, with consequential coverage and capability differences). Flexibility in spectrum use ability for MNOs to acquire different spectrum amounts and ability for verticals and/or other sub-national operators to gain access to spectrum (and/or for new business models to emerge) could be aided if 5G licenses allow for spectrum leasing to occur. 'sub-leasing', 'use-it-or-lease-it' or 'national roaming' conditions to be attached to licenses could serve well MNOs needs as well as vertical industries while ensuring an efficient use of spectrum and incentivize investments in the 26 GHz band.
- When considering vertical industries needs in the mmWave spectrum, it is important to highlight that network virtualisation in 5G will provide the opportunity for networks to cater for diverse vertical market needs, with different performance requirements, via network slicing. Hence, different types of deployment can be catered for via the same network, without needing to assign specific spectrum for each different use.
- Last but not least, the bandwidth needed per operator in bands such as 26GHz is expected to be in multiples of 100MHz. It is noted that considering that in 3.5 GHz on 100 MHz contiguous spectrum it would be possible to achieve peak t-put in the

order of 3Gbps, higher peak t-put in the 26 GHz band could be achieved with chunks of spectrum of at least 400 MHz of contiguous spectrum. Thus, Qualcomm recommends Spain to design auction enabling operators to deploy 5G over large contiguous spectrum of at least 400MHz.

Question 20

Organización y licitación de la banda de frecuencias de 1,5 GHz¿Cuál considera que sería la distribución en bloques de frecuencia más eficiente teniendo en cuenta la situación existente? ¿Cuándo debería licitarse y bajo qué modelo: concurso o subasta? ¿Cuál sería el ámbito geográfico idóneo de las concesiones a licitar?

The 1427-1517 MHz is extremely attractive for MNOs.

Since carrier aggregation between low bands (700, 800, 900 MHz) is very difficult, the only way to augment the performance of MNOs' coverage layers is to pair one such low bands with bands above 1 GHz. In that context, the 1427-1517 MHz has many advantages as it combines support for large bandwidth (20MHz) with very wide coverage: through SDL, the MNO can raise the radiated power in 1427-1517 to compensate for the difference in propagation with its anchor carrier in bands below 1GHz.

In other words, an MNO can reuse its 800/900 MHz sites and augment them with 1427-1517, in order to more than triple the DL speeds of its coverage layer. This will be especially critical as 5G will be deployed in 3400-3800 mostly in dense area, in order to avoid a significant drop of quality when the user moves from the city center to suburban and rural areas.

Ideally the whole band should be awarded but even just 40 MHz of 1452-1492 MHz can have a significant impact for at least 2 MNOs in augmenting the performance of their coverage layer. For example, an MNO may decide to use the L-band to provide 5G service differentiation with LTE (30 MHz DL instead of 10 MHz DL) over the whole network footprint, instead of having the 5G experience limited to pockets of deployment in large cities.

Qualcomm considers 20 MHz as the optimal channel BW for LTE and enables a cost-effective network upgrade. Narrower channel bandwidth would provide less benefits for the same cost, larger channel bandwidth cannot easily be leveraged by the current LTE technology.

Qualcomm recommends Spain to select an award procedure enabling as potential outcome the deployment of at least 2 networks of 20 MHz and recommends to accelerate the refarming of whole 1427-1517 MHz band.

Question 21

Otras bandas de frecuencia para 5G ¿Considera que existen otras bandas de frecuencia para proporcionar servicios 5G que debería ponerse en España a disposición del sector antes de 2020 y bajo qué modelo?

Qualcomm understands the current situation in Spain on the 700 MHz band and on the intention of the Government to have an ad-hoc process. That said, Qualcomm encourage Spain to make available the 700 MHz band ideally by 2020 as this would lead to substantial benefits. The importance of the 700 MHz band is not only due to its large coverage benefits, but also to the role it is expected to play for the future of 5G in Europe, as recently highlighted by RSPG that has identified this band as a 5G pioneer band in Europe. Late availability of the 700 MHz may have negative consequences on Spain's ambitions in 5G.

The 700 MHz could play a big role to enable new services and connectivity leading to 5G should also be taken into account when addressing the optimum use of the center gap. Throughout Europe, 5G is expected to deliver not just improved mobile broadband, but critically a technology platform for the emergence of so-called verticals. 5G technology will enable verticals such as M2M/IoT and broadcasting to benefit from performance and economies of scale that can only be delivered by the mobile ecosystem. Such verticals and services will be based on new business models and on partnerships between vertical players, mobile technology vendors and network operators – in other words vertical services will be supported by a horizontal 5G technology ecosystem. Vertical services over 5G have the potential to deliver the next growth phase for both the vertical domains considered and the mobile ecosystem.

Furthermore, the 738-758MHz band has recently been standardized by 3GPP as the E-UTRA SDL Band 67. Support for the band in chipsets and terminals will depend on market demand, noting that the band overlaps with the internationally harmonized 700 MHz band (3GPP band 28).

Moreover, a recent Analysys-Mason study highlighted the significant benefits that the 733-736/788-791 MHz would provide for the emergence of M2M/IOT services supporting QoS.

Qualcomm recommends AGCOM to award the 733-736/788-791 MHz to an MFCN network und spectrum award procedure designed to favour networks delivering M2M/IOT services. While the 733-736/788-791 MHz has been discussed in the context of PPDR services, Qualcomm notes that significant uncertainty is surrounding the PPDR plan, and that 2x3 MHz would not be sufficient to provide adequate service to PPDR professionals. A model such as the UK Emergency Service Network seems much more realistic to deliver quality services to PPDR professional in a timely manner. If PPDR services have an absolute requirement to access the 733-736/788-791 MHz, sharing between PPDR and IOT/M2M services could provide priority to PPDR services without endangering the emergence of IOT/M2M services.

Question 22

Pilotos de despliegue de red ¿Considera que deberían realizarse pilotos de despliegue de red? ¿Cuál debería el alcance y la extensión de los mismos? ¿Cuándo deberían realizarse a la luz de la evolución de las normas técnicas? ¿Sobre qué bandas de frecuencia deberían realizarse? ¿Qué aplicaciones considera deberían desplegarse sobre los pilotos urbanos de 5G y cuál debería ser el grado de cobertura qué se debería obtener? ¿Cuál debería ser el papel de la Administración? ¿Se debe adoptar algún modelo de colaboración público privada?

With large commercial introduction of 5G networks taking place by 2020, it is expected that the early introduction of 5G in Europe will benefit from trials and pilots of new 5G networks taking place well before this. Mobile operators and manufacturers have already begun to invest in research on 5G technology, as well as carrying out initial trials in a number of European Member States. These trials are expected to increase in scale and number over the coming twelve months as European policies encouraging the development of 5G (such as proposed in the 5G Action Plan) are further developed. Qualcomm believe that trials should be using the priority bands identified by the European Commission in its action plan (700MHz, 3.4 – 3.8 GHz and 26 GHz) and could start as soon as in 2017. It would be important that such potential trials would not delay the release of spectrum and the deployment of 5G in the country but on the contrary should be used to accelerate its release and pave the way to a faster deployment. Qualcomm recommends to integrate such potential trial initiatives as much as possible into broadband national plans and to involve as

much as possible local eco-system players including research centers and universities in addition to global 5G players. To this extent, Government funding could help in particular local small and medium enterprises to join such initiatives. Qualcomm expect the first deployments to focus on MBB use cases and trials should focus on them to pave the way and accelerate first 5G deployments. In parallel, as a number of industries and sectors are expected to benefit from 5G, Qualcomm recommends to gather requirements from the so called vertical markets. This is important to ensure that the requirements of sectors such as ITS, Industry 4.0, mobile health, PMSE, PPDR are taken into account.

Appendix I

The importance of wide channel bandwidth in the order of 100MHz per operator

By design, 5G NR (New Radio) will optimally support wideband operation, allowing operators to fully take advantage of larger allocations of contiguous spectrum to increase peak rates and user experience, with manageable terminal complexity and minimal power consumption.

Ongoing standardization for the 5G NR new air interface in 3GPP is considering bandwidth in the order of 100MHz.

5G-NR specification will provide a full set of new features that will allow leveraging large bandwidths in a differentiating way compared to latest releases of LTE Advanced Pro, thus providing better average performances or better capacities at equivalent bandwidth and proportionally amplified by the use of large channel bandwidth.

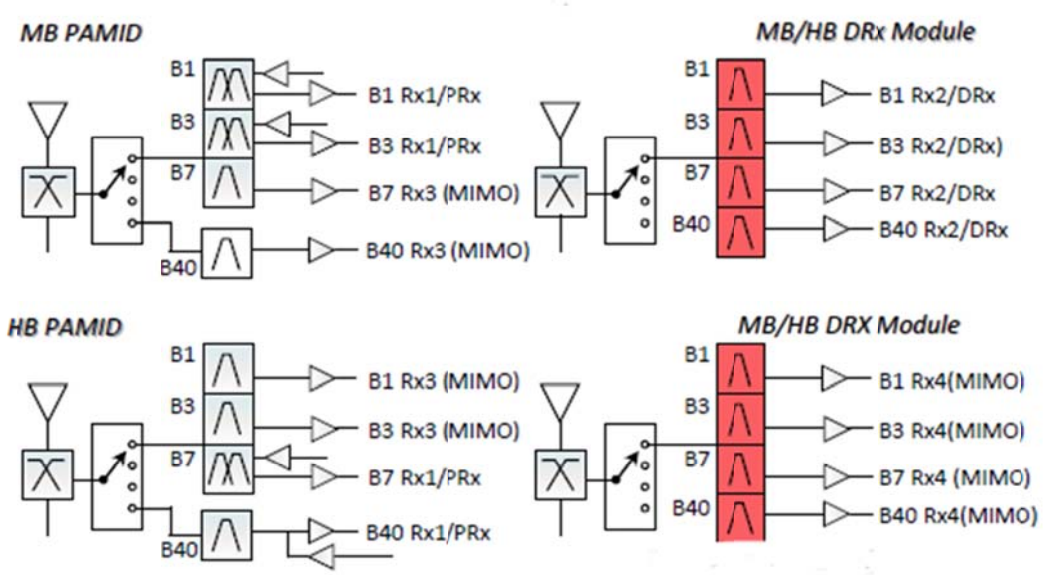
- Enhanced active multi-element antenna systems leveraging latest High Order MIMO, with beamforming capabilities on both DL and UL will be delivered by design when using mmW frequencies for 5G-NR and will also be available to 3.4-3.8 GHz 5G-NR. These new generation of 2-dimensional antenna arrays allow better control of interference through directional transmissions to users and minimisation of transmitted power and additional capacity enhancements.
- In particular, the 5G NR slot structure is being designed to have a more flexible TDD integrated sub-frame design with the efficient embedding of uplink reference signal transmissions to enable massive multiuser MIMO based on channel reciprocity (i.e. the ability to estimate the channel without relaying large amounts of channel estimation side information). Compared to LTE MIMO, these 5G NR shorter latency wideband sounding signals enable robustness to channel variability.
- Qualcomm is currently working on new simulations to highlight the benefits of using these new active antennas solutions together with wideband channels and 5G-NR.
- As an example, massive MIMO at 3.6GHz allows re-use of existing macro sites at same transmit power to obtain a significant throughput gain at cell edge. Simulations have been carried out using the following characteristics:
    - macro cell deployment with inter-site distance of 1.7 km,
    - 46dBm transmit power at base stations,
    - 10 users per cell and
    - 24 column antenna array per cell and 4 antennas per UE at 4 GHz using an 80 MHz channel.

This provides 3.9x to 4.1x gains for cell edge and median users, respectively, compared to 2 x 4 MIMO using the same 80 MHz bandwidth at 4 GHz and delivers an average cell throughput of 808 Mbps.

- The massive MIMO designs enable MU-MIMO (Multi-User MIMO) to be able to simultaneously serve multiple users in the same spectrum and cell at the same time based on the increased level of directional transmission to separate users. Applied to large bandwidths, the absolute gains become significantly attractive to cope with new usages related to eMBB.

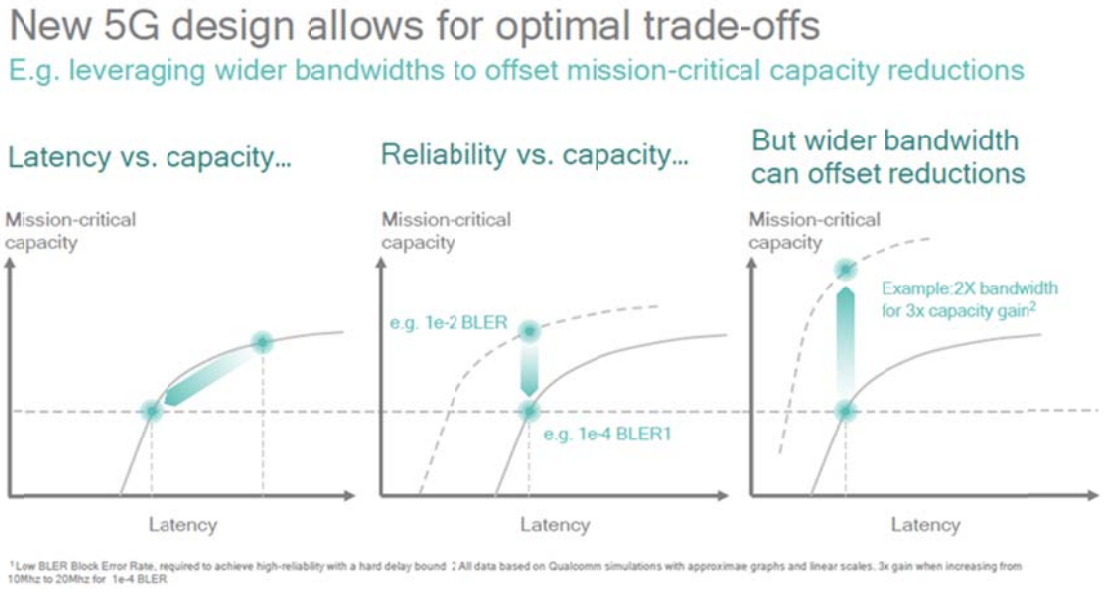
- It is therefore important to highlight that key element for successful deployment of massive MIMO and active antennas is the availability of large contiguous bandwidths. Considering channel reciprocity, the highest gains are expected in TDD deployments which allow the 5G NR system to leverage channel information without the need for large amounts of channel state information transfer between terminals and cell sites. The enhanced spatial directivity from Massive Multiuser MIMO at the 3.4-3.8 GHz band causes less interference to other users and cells which translates into a capacity gain as well as energy consumption savings on the network side since the signal is effectively steered to each of the desired users vs being transmitted in a broader spatial area.

- 5G-NR on large bandwidths will reduce terminal front end complexity and power consumption compared to LTE using multiple 5 to 20 MHz carrier aggregations to exploit a similar large bandwidth.
    - By being able to work on wideband carriers and by using flexibility in sub-carrier spacing, 5G-NR enables efficient RF front end and baseband processing to have improved power consumption per Mbps and per MHz.



Example: Mid-Band (MB) / High-band (HB) RF front-end with 4x4 MIMO for B1-B3-B7-B40

- 5G-NR on large bandwidths allow to improve access to ultra-reliable services by offsetting mission critical capacity needs and access to new generation of services by bringing native forward compatibility for straight forward launches with limited impact on legacy services.



LTE can use Carrier Aggregation to aggregate multiple 20MHz channels, but as described above, as the number of channels to be aggregated increases, LTE will become less inefficient than an 5G NR system designed to inherently leverage wideband TDD deployments and massive MIMO

By delivering improved link budget, better spectrum efficiency in higher bands such as 3.4-3.8 GHz, 5G-NR will improve peak and average data rates experienced in similar channel bandwidths.

The following table provides theoretical 5G data rate per channel BW.

RF channel Bandwidth (MHz)	Peak data rates[2]	Average data rates[3]	5th percentile data rates[4]
40	1.2 Gb/s	0.312 Gb/s	9 Mb/s
100	3 Gb/s	0.78 Gb/s	22.5 Mb/s
200	6 Gb/s	1.56 Gb/s	45 Mb/s
400	12 Gb/s	3.12 Gb/s	90 Mb/s

5G-NR will also bring the ability to "multiplex" new forward compatible services with limited impact on eMBB capacity needs and the ability to deliver simultaneous wireless backhauling and fronthauling capabilities to gNBs (5G-NR base station). Wide bandwidths channel will significantly facilitate the use of these capabilities and therefore contribute to the acceleration of new services introduction.

To sum-up, it can be said that 5G NR is being designed to inherently incorporate advanced wireless techniques across a wide range of requirements that take full benefit of wideband channels to deliver improved spectral efficiency, better capacities and user experiences Wide contiguous spectrum assignments to operators in the order of 100 MHz or more will allow operators to reap the full benefits of the 3400-3800 MHz frequency range for 5G.

[2] *Peak spectral efficiency (SE) of NR: 30 bit/s/Hz in DL (from draft New Report IMT-2020.TECH PERF REQ in ITU-R WP 5D). Peak data rate in IMT-2020.TECH PERF REQ is 20 Gbit/s in DL (roughly equivalent to a total of 667 MHz with the considered SE).*

[3] *Average SE of NR: 7.8 bit/s/Hz in DL for Dense Urban scenario (3 x SE of IMT-Advanced, also considered in IMT-2020.TECH PERF REQ)*

[4] *5th percentile SE of NR: 0.225 bit/s/Hz in DL for Dense Urban scenario (3 x SE of IMT-Advanced, also considered in IMT-2020.TECH PERF REQ). User experience data rate in IMT-2020.TECH PERF REQ is 100 Mbit/s in DL (roughly equivalent to a total of 444 MHz with the considered SE). Studies in ITU-R are still ongoing regarding these numbers also in the context of the spectrum needs of IMT-2020 above 24 GHz.*

Please find attached the following white papers:

- augmented-and-virtual-reality-the-first-wave-of-5g-killer-apps
- heavy-reading-whitepaper-exploring-the-potential-of-mmwave-for-5g-mobile-access
- ihs-5g-economic-impact-study
- whitepaper-making-5g-nr-a-reality
- qualcomm-snapdragon-x50-5g-modem-infographic