Qualcomm Europe Inc.

Call for input on 5G spectrum access at 26 GHz

Qualcomm Response

Introduction

Qualcomm is pleased to provide its views on Ofcom Call for Inputs (CFI) on "5G spectrum access at 26 GHz and update on bands above 30 GHz". The 26 GHz band offer a tremendous opportunity for the deployment of 5G services in the UK as early as 2019. This band will enable multi-gigabit data rates 5G connectivity, with dense spatial re-use and flexible configuration of spectrum, enabling both access and backhaul services to be provided. Qualcomm strongly supports the progressive release of the band starting with the 26.5 – 27.5 GHz range first in 2018.

Qualcomm strongly believes in mmWave, and in particular 26 GHz, as a fully mobile system. Indeed, Qualcomm has invested heavily in research to fully understand mmWave performance under various mobility conditions and to commercialize the system for mobility from day one. This was partly done to solve the "harder problem" as by enabling a fully mobile mmWave system, an FWA implementation can then be derived, which is by nature less demanding

Availability of new spectrum in both the 3.5GHz and 26GHz bands is the key to unlocking the full potential associated with 5G. Indeed at 3.5 GHz operators can expect to get in excess of 2 GBps peak rates over 100 MHz of contiguous spectrum., while at 26 GHz, blocks of 400 MHz of contiguous spectrum will give well in excess of 2 GBps and possibly twice that depending on the use of higher order modulation techniques. By combining these exciting new capabilities with the under-laid Gigabit LTE coverage in the Non-Stand Alone (NSA) 5G architecture, the end user will soon experience truly uniform fiber-like performance. The promises of 5G will be delivered through the combination of Gigabit LTE and 5G NR in both 3400-3800 MHz and 26 GHz.In countries, like the UK, where scarcity of spectrum in the 3.4 – 3.8 GHz band is expected until 2020, Qualcomm believes that a timely award of this band, no later than in 2018, will be vitally important for the deployment of 5G services in 2019.

At first, it is expected that operators will focus on enhanced Mobile BroadBand (eMBB) and Ultra Reliable Low Latency Communications (URLLC) usage scenarios for dense urban, urban and suburban scenarios. Diversified rollout scenarios including indoor hotspot, dense urban, urban and rural macro will also be addressed. Applications such as Mobile Virtual/Augmented Reality and Ultra High Definition Video, 5G fixed wireless access services and smart home, smart manufacturing, Health care could benefit from 5G deployments.

Qualcomm supports Ofcom's approach for a progressive release of this band starting with the 26.5 – 27.5 GHz range in 2018 to enable commercial 5G services in 2019. This is in line with the RSPG opinion on 5G that calls member states to make part of the band available before 2020. It will enable the UK to lead on 5G deployments in Europe and to catch up with ongoing developments in US/Korea and Japan allowing the earliest opportunity for the development of new services and applications in a real world commercial situation (as opposed to technology trials). Focusing on the 26.5 – 27.5 GHz band in a first phase will also provide the benefit of leveraging the wide and global eco-system of equipment, devices and chipsets leveraging on mmWave deployments in the US, Korea and Japan.

In particular, it could be useful for Ofcom to know that the first commercial devices featuring Qualcomm Snapdragon X50 5G NR modems are expected to be available as early as 2019. [✂]

Furthermore, Qualcomm believes that in order to help establish the 5G market in the first take off phase it is recommended that mobile operators have access to the 26.5 – 27.5 GHz through exclusive national licenses in high density areas. Qualcomm equally believes Ofcom should design an award enabling the deployment of 5G mobile operators' networks over large contiguous spectrum of at least 400MHz. This will bring considerable benefits in terms of 5G connectivity in the UK. The so-called verticals, such as factories, stadiums, etc, could access the spectrum using network slicing of MNOs' networks, joint vertical-MNO deployment of networks and/or spectrum sub-leasing. An additional option that Ofcom could explore is to reserve a small separate sub-band (not wider than 200 MHz) in the upper 1 GHz or in the lower part of the 26 GHz band, subject to market demand and associated timing, for geographic/local licences. Such authorization, to be issued on a demand basis, would suit the requirements of verticals who wish to use the spectrum only in restricted geographic locations (ranging in size from regions to individual premises).

5G Equipment and Technology Availability

Question 2.1: What are your planned timelines for commercial availability of network equipment and devices for the 26 GHz band? When will equipment for testing and trials be available? Please specify the specific mmWave tuning ranges supported and their timing.

Qualcomm and other mobile industry leaders are working hard on the development of 5G NR specifications. At least two bands will be defined for 5G NR in 24.25-29.5GHz frequency range: 24.25-27.5 and 26.5-29.5GHz with the target for completion in Release 15. Pre-standard equipment and devices are already available and trials well underway in different parts of the world. In particular, amongst other, Qualcomm announced the following:

- Plans to conduct interoperability testing and over-the-air field trials in Japan with NTT DOCOMO and ERICSSON on the 5G New Radio (NR) specifications. The trials will operate in mid-band spectrum, as well as millimeter wave (mmWave) spectrum at 28 GHz, showcasing the unified 5G NR design across diverse spectrum bands.
- Plans to conduct interoperability testing and an over-the-air field trial based on the expected 5G New Radio (NR) specifications with Ericsson and Telstra. The trial will highlight new 5G NR

technologies that utilize wide bandwidths available at higher frequency bands to increase network capacity and to provide up to multi-gigabit per second data rates.

- Plans to conduct interoperability testing and over-the-air field trials based on the expected 5G New Radio (NR) specifications with Ericsson and AT&T. The trials will support operation in mmWave spectrum, aiming to accelerate commercial deployments in the 28GHz and 39GHz bands.

Furthermore, Qualcomm recently announced the expansion of its 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. The first commercial devices featuring Snapdragon X50 5G NR modems are expected to be available in 2019. [✂]

Question 2.2: Given the 3GPP studies into NR-based operations in licence-exempt spectrum, when (if ever) do you expect to support licence exempt operation and/or coordinated sharing in the 26 GHz band in your products?

Although 5G will be using both licensed and unlicensed spectrum, Qualcomm strongly believe that the 26 GHz band would be to be awarded on a licensed basis. We do agree with Ofcom view that 'uncoordinated deployment of small cells, as would be the case in a license exempt regime, risks a 'tragedy of the commons' situation in which operators are unable to deliver the required capacity and QoS due to excessive spectrum congestion and interference. The risk is increased when the number of unique channels available within the band is small.' Licensing approach for 5G in the 26 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 MBB and other ultra-reliable, low latency use cases.

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. 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. 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.

Thus, in order to help establish the 5G market in the first take off phase it is recommended that mobile operators have access to the 26.5 – 27.5 GHz through exclusive national licenses in high density areas. Qualcomm equally believes Ofcom should design an award enabling the deployment of 5G

mobile operators' networks over large contiguous spectrum of at least 400MHz. This will bring considerable benefits in terms of 5G connectivity in the UK. The so-called verticals, such as factories, stadiums, etc, could access the spectrum using network slicing of MNOs' networks, joint vertical-MNO deployment of networks and/or spectrum sub-leasing.

An additional option that Ofcom could explore is to reserve a small separate sub-band (not wider than 200 MHz) in the upper 1 GHz or in the lower part of the 26 GHz band, subject to market demand and associated timing, for geographic/local licences. Such authorization, to be issued on a demand basis, would suit the requirements of verticals who wish to use the spectrum only in restricted geographic locations (ranging in size from regions to individual premises).

Question 2.3: When do you expect to support standalone New Radio in the 26 GHz band in your products?

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 commercial 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.

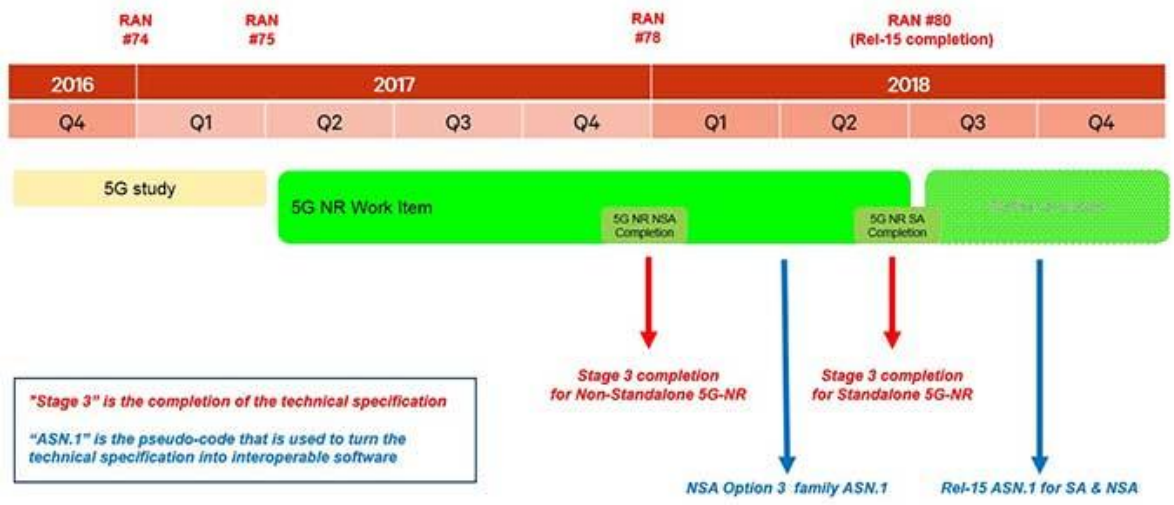


Figure 1: 3GPP work plan for 5G NR Release 15

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.

It is expected that 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. It is expected that the first products will support NSA architecture, followed by a second wave of products supporting SA.

The 26 GHz Band

Question 3.1: Are there any other aspects related to the existing use of 26 GHz not covered in this CFI that you believe need to be considered?

No

Question 3.2: What options for the existing services in the 26 GHz band do you believe need to be considered to allow for the introduction of new 5G services? Please give as detailed a response as possible along with all relevant information and explain how you would see any potential option you provide working in practice.

An exclusive band for 5G would provide appropriate incentives to MNOs to invest in deployments, thus facilitating the fast take up. However, it is recognized that the propagation and intended use cases above 6 GHz might enable coexistence with incumbents (in some specific cases), compared to co-existence in bands below 6 GHz.

In general, Qualcomm is of the view that it could be possible to preserve some of the existing earth stations in the Fixed Satellite Service (FSS), the Space Research (SR) service and the Earth Exploration Satellite Service (EESS), in case they are placed in remote areas. Protection against 5G networks could be arranged by defining exclusion zones around the Earth stations. In practice, this means that 5G providers could be awarded national licenses with a number of well-defined areas around the Earth stations, where 5G use is not allowed or is severely limited. New Earth stations should only be authorized following a commercial agreement between the Earth station operator and the 5G licensee. Qualcomm believes that these kind of agreements can be achieved between 5G licensees and Earth station operators, especially, at remote locations where 5G is unlikely to be deployed in 26GHz band.

It may not be feasible to share a 26 GHz band in the same geographical area between traditional ubiquitous point to point links and 5G. Point to point links require a high reliability and it will be difficult to ensure this if the 26 GHz band is shared. Qualcomm is of the view that fixed links should be refarmed to another frequency band in advance of the spectrum being released for 5G. However, it is recognized that there are a high number of fixed links deployed in the 24.5-26.5 GHz block, which can create an obstacle to release the whole band for 5G. For this reason, it is recommended to release first the 26.5 – 27.5 GHz to facilitate fast deployment of 5G and in the longer term, a solution is needed for the lower part of the 26 GHz band. It is also noted that, as the fixed link operators are often the same as the expected 5G operators, there may be ways to agree with the operators, how they can use the same frequency band for 5G in densely populated areas and for backhauling in other areas.

Question 3.3: Should a moratorium be placed on issuing new licences in the 26 GHz band for existing services? E.g.to ensure that the 26 GHz band is not unnecessarily encumbered prior to the development of a new authorisation / licensing approach for 5G services?

Yes. Qualcomm believes that Ofcom should start as soon as possible the appropriate spectrum management activities to facilitate availability of the band for 5G services.

Understanding spectrum demand

Question 4.1: What service would be delivered and to which consumer and/or organisations?

Qualcomm believe that 26 GHz band will enable multi-gigabit data rates to be delivered within 5G networks, with dense spatial re-use and flexible configuration of spectrum, enabling both access and backhaul services to be provided. At first, it is expected that operators will focus on eMBB and URLLC usage scenarios for dense urban, urban and suburban scenarios. Diversified rollout scenarios including indoor hotspot, dense urban, urban and rural macro will be addressed. Applications such as Mobile Virtual / Augmented Reality and Ultra High Definition Video, 5G fixed wireless access services and smart home, Smart manufacturing, Health care are areas where services could benefit.

The multi-gigabit data rates possible with mmW technology and the wide bandwidths available in 26GHz will likely enable new use cases benefiting from high instantaneous data rates. On one hand, end users, who could be individual consumers, or machines (e.g., cars), will be able to download large amounts of data very quickly e.g., a movie before boarding a flight, or a high definition map update to a vehicle. On the other hand the network will be able to serve a lot more highly demanding end points as the high instantaneous peak rates combined with multi-user MIMO (MU-MIMO) will dramatically increase network capacity.

Question 4.2: Where in the UK would the 26 GHz spectrum be used to deliver services? For example, will deployments be focussed on:

a) Areas of existing high mobile broadband demand?

Yes

b) Rural areas?

Yes, but not in the sense of rural wide area coverage.

c) Rail and road corridors?

Yes

d) Specific types of enterprise or industrial sites?

Yes. It is important to highlight that network virtualization 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.

e) Indoors or outdoors?

Yes, both.

f) Specific nations or regions of the UK?

It might be expected that initial 26GHz mobile deployments will be focussed on major metropolitan urban areas and significant suburban & urban areas. Areas underserved by broadband with 5G FWA, industrial & research areas and transport corridors will also be served over time.

Question 4.3: Where 5G cells are deployed, are they expected to be individual cells or as clusters of cells required to give wider areas of contiguous coverage? What would be the area of a typical contiguous coverage cell cluster?

5G will enable operation on multiple frequency bands ranging from sub-1GHz up to mmWave 20GHz and beyond. Different frequency bands will have different propagation, especially when we consider such a wide range. We will need to differentiate at least two cases: sub-6GHz bands and mmWave bands. Sub-6GHz bands (and in particular the 3.5GHz band) are expected to be used to provide coverage at macro layer. Still, in order to reuse existing sites while employing high bands (such as 3.5GHz), operators will need to deploy large Massive MIMO Radio Remote Units, which are capable to provide similar coverage as mid bands (e.g., 1800MHz) by the use of a large number of active antenna elements. While providing the necessary coverage, Massive MIMO will at the same time increase the capacity of the macro cell. We envision that capacity will be an important metric for 5G, as the amount of traffic will be burgeoning in the coming years with the more widespread adoption of competitive data plans comprising unlimited use of popular apps, video streaming or even full unlimited data usage. The capacity increase, however, will not be uniform across the network, it will rather be concentrated in specific hotspots (cafes, venues, public squares, city centers, etc). The new capacity needs might be confronted also with the strategic deployment of high-capacity small cells covering the hotspot area. This is how we envision mmWave to be deployed in the first wave of 5G. mmWave in fact is essentially a technology that brings the benefits of Massive MIMO down to a small-cell scale, hence maximizing small cell capacity and hotspot coverage. The scale of mmWave small-cell deployment will depend on the scale of the urban hotspot an operator will need to cover. As mentioned before, those would essentially encompass venues (e.g., stadiums) and locations within city centers. The latter case could be the most challenging one, as it would entail covering an area of 1-2 km^2. However, depending on traffic patterns, it could be even sufficient to cover only the main public squares and roads within the city center, as those would be the locations where most traffic is consumed.

Question 4.4: What capacity and bandwidth (i.e Channel Bandwidth in MHz) would be required at each cell to meet initial capacity requirements? How will this change over time?

Qualcomm believe that the bandwidth needed per operator 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 throughput in the order of 3Gbps, higher peak throughput in the 26 GHz band could be achieved with chunks of spectrum of at least 400 MHz of contiguous spectrum. Thus, Qualcomm recommends Ofcom to license the band in a way that could enable the deployment 5G mobile operators'

networks over large contiguous spectrum of at least 400MHz. Over time, we expect deployments to become denser.

Question 4.5: What quality of service is required? How sensitive is the service being offered to variations in radio interference from other operator's 5G cells and other spectrum users?

As with any other cellular system, 3GPP will define mechanisms for managing interference in mmWave systems. Indeed, mmWave will be deployed in combination with massive and multi-user MIMO techniques (MA-MIMO and MU-MIMO) use tight beamforming, scanning and tracking, to direct communications very narrowly between sender and receiver. In that sense mmWave communications are very effective in isolating not only algorithmically, but also spatially communications paths e.g., between multiple end users and a given set of gNBs.

Question 4.6: Will end users be fixed or mobile?

Qualcomm strongly believes in mmWave as a fully mobile system. Indeed, Qualcomm has invested heavily in research to fully understand mmWave performance under various mobility conditions and to commercialize the system for mobility from day one. This was partly done to solve the "harder problem" as by enabling a fully mobile mmWave system, we can then easily derive an FWA implementation, which is by nature less demanding.

In that sense both mobile and fixed users can be served by mmWave.

Question 4.7: What are the characteristics of 5G at 26 GHz which make this band particularly suited to the service you plan to deploy? What other spectrum bands could be used as an alternative, or in preference to, the 26 GHz band? To what extent could carrier aggregation and other techniques reduce your reliance on 26 GHz?

Qualcomm believe that the 26 GHz band can accommodate wide channels important for high capacity 5G eMBB delivery. This band strikes a good balance between the availability of wide bandwidth and the feasibility of the technical solutions that can readily developed to use these frequencies. Furthermore, the upper 1GHz of this band have the potential to re-use equipment and devices available in other regions of the world as there is an overlap between the Korean/US bands (28 GHz) and the European 26 GHz band.

Carrier Aggregation has been a very effective technique in stitching together component carriers from the same and different bands. There is, however, always some cost associated with this in terms of both transmission efficiency and complexity. One of the big advantages of 5G NR and the new frequency bands it operates in, is the ability to handle much wider component carriers which provide both relative simplicity and efficiency. In the higher frequencies, availability of ever wider bands makes this a unique selling point.

Spectrum Authorisation

Question 5.1: Should Ofcom consider licencing options other than the 3 examples set out above (licence exempt, shared coordinated and area defined) for the 26 GHz band? If so, what other options do you consider should be included?

Please see answer to question 2.2 for Qualcomm view on licensing for the 26 GHz band.

Question 5.2: What methodologies could be used to pre-define 'high demand areas' for area defined licences?

As highlighted in the answer to question 2.2, in order to help establish the 5G market and ecosystem in the first take off phase it is recommended that operators would be awarded exclusive nationwide licenses in high density areas in the 26.5 – 27.5 GHz. Verticals, such as factories, stadiums, etc, can access the spectrum using network slicing of MNOs' networks, joint vertical-MNO deployment of networks and spectrum sub-leasing. An additional option that Ofcom could explore is to reserve a small separate sub-band (not wider than 200 MHz) in the upper 1 GHz or in the lower part of the 26 GHz band, subject to market demand and associated timing, for geographic/local licences. Such authorization, to be issued on a demand basis, would suit the requirements of verticals who wish to use the spectrum only in restricted geographic locations (ranging in size from regions to individual premises).This range of options could strike a reasonable balance between establishing the market with MNOs by providing them with large contiguous spectrum of at least 400 MHz and finding a pragmatic solution to enable verticals and ensuring spectrum does not sit fallow.

Question 5.3: What mechanism could be used to coordinate cell deployments by different operators in shared spectrum?

Qualcomm would like to indicate that a study item in 3GPP has been approved and is aiming to provide technology enablers for new sharing paradigms (including mechanisms for coordinated sharing). These studies are in their initial stages and their scope and outcomes will not be available in Rel. 15 and thus not relevant for early deployments by 2020. [✂]

Question 5.4: What methodologies could be used for determining the proportion of spectrum to allocate using area defined licences and coordinated deployment?

Given Ofcom intention to make available 1 GHz of spectrum in the 26.5 – 27.5 GHz for rollout in the 2019 timeframe and considering that Qualcomm believes that to establish the market in a first phase, mobile operators should have access to large bandwidth of spectrum on an exclusive nationwide licensed basis in high density areas and Ofcom should enable the deployment 5G mobile operators' networks over large contiguous spectrum of at least 400MHz. Ofcom could also explore the option to reserve a small separate sub-band (not wider than 200 MHz) in the upper 1 GHz or in the lower part of the 26 GHz band, subject to market demand and associated timing, for geographic/local licences.

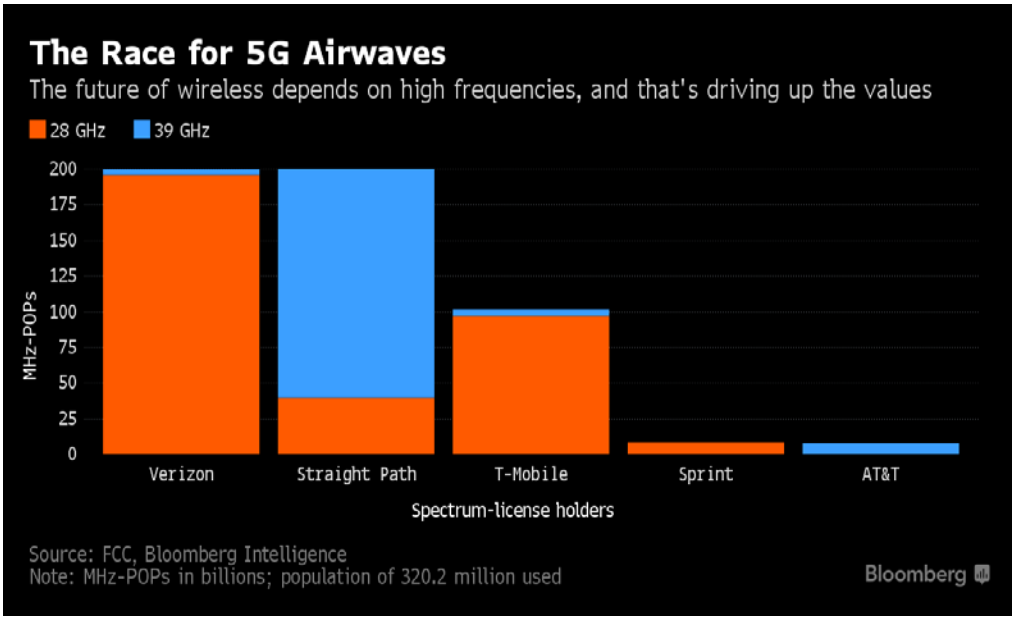
Question 5.5: Do you agree that the 26 GHz band should be released progressively? What risks do you envisage with such an approach and how can these be best mitigated?

Qualcomm agrees that the 26 GHz band should be released progressively. Qualcomm strongly supports to the release the 26 GHz band starting with the 26.5 – 27.5 GHz range first in 2018.Thisis in line with the RSPG opinion on 5G which recommends member states to make part of the band available before 2020. This will enable the UK to lead with 5G deployments in 2019 and to catch up with ongoing developments in US/Korea and Japan allowing the earliest opportunity for the development of new services and applications in a real world commercial situation (as opposed to technology trials).

Qualcomm envisages spectrum in the upper part of the 26GHz band being deployed in the 2019 timeframe supported by a wide and global eco-system of equipment, devices and chipsets leveraging on mmWave deployments in the US, Korea and Japan. Across Europe, the 24.25-26.5 GHz block might have heavy use and a number of European countries are targeting to release the upper 1 GHz first in 2018 timeframe.

Outside Europe:

- Korean regulators are planning to allocate a total of 4 GHz of millimeter wave spectrum for 5G in three phases. The first phase will begin in 2018, focusing on millimeter wave in 27.5 – 28.5 GHz. Phase two will add 2 GHz of bandwidth in the 26.5 – 27.5 GHz and 28.5 – 29.5 GHz ranges. The third phase will add an additional 1 GHz of bandwidth in the 2021 to 2026 timeframe, for a total 5G mmWave bandwidth of 4 GHz. Around 28 GHz (26.5-29.5 GHz) has been identified for a 5G trial service at the 2018 winter Olympics. Three operators in Korea have been allocated 1 GHz each in this range for the purposes of the trial.
- In July 2017, Japan's MIC (Ministry of Internal Affairs and Communications) officially identified and issued a public consultation concerning 5G spectrum identifying up to 2 GHz of millimeter wave spectrum, to come from the 27.5-29.5 GHz range. MIC plans to issue the final technical rules, including the precise frequencies, by next summer.
- In China, MIIT is currently consulting on the use of the 24.75-27.5 GHz and 37-42 GHz bands for IMT-2020/5G.
- In the US, 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. The race for 5G airwaves in the US has been well described in the picture below by FCC/Bloomberg.



A phased approach may result in fragmentation, when individual operators obtain spectrum blocks in both sub bands. A technology solution to this problem could be carrier aggregation. Regulatory measures could be considered by Ofcom but also market forces could help solving this problem. As a result of that, Qualcomm believes that it will be essential that Ofcom give clear guidance as soon as possible of when the rest of the band would be released. This would allow operators to choose between bidding at the early release or later at the time of release of the rest of the band, depending on their business needs.