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February 15, 2017

Radio Spectrum 5-Year Outlook
Radio Spectrum Management
Ministry of Business, Innovation and Employment
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Re: Spectrum Outlook 2017 - 21

Qualcomm Incorporated appreciates the opportunity to provide comments to the Ministry of Business, Innovation, and Employment on its *Draft Radio Spectrum Five Year Outlook 2017-2021*.

Qualcomm is a world leader in 3G, 4G and next-generation wireless technologies. For more than 30 years, our ideas and inventions have driven the evolution of digital communications, linking people everywhere more closely to information, entertainment and each other. Qualcomm is the world's largest fabless semiconductor producer and the largest provider of wireless chipset and software technology, which power many wireless devices available today. We are a recognized world leader in advanced wireless technologies and continue to bring technology enhancements to market. Qualcomm's philosophy has always been to enable many other companies in the value chain to succeed. Today, we license nearly our entire patent portfolio to more than 275 manufacturers worldwide – from new market entrants to large multinational companies. Qualcomm's business model has created a pro-competitive, pro-innovation value chain of global scale that ultimately benefits consumers.

The remainder of this submission corresponds to the Consultation Draft as per the headings in bold below. This submission highlights some current and expected developments from the perspective of the mobile industry and does not preclude other developments that may eventuate during the 5-year outlook timeframe that Qualcomm may wish to provide comment on or that would necessitate a review of the outlook.

Spectrum Trends Driving Change

Globally, mobile data traffic is exploding and the industry is preparing for an astounding 1000x increase. Qualcomm is leading the charge through its innovations and leading products in preparing

the industry to meet this mobile data challenge. Technology solutions include a combination of increasing the efficiency of existing assets, employing more resources in the form of small cells and spectrum, as well as adopting radically different ways of acquiring, deploying, operating, and managing these resources. Additional spectrum will continue to be essential to supporting mobile broadband (MBB) growth.

Innovations and technology advancements in MBB have enabled the wireless industry to impact almost every aspect of people's lives. The mobile phone has become the largest information platform in the history of humankind. While the global scale of mobile telephony and its economic impacts are well understood by ICT industry participants and governments today, we envision that MBB, with its ability to connect people to the Internet in an ultra-personal and pervasive manner, will have a far greater impact. MBB, or high-speed access to the Internet and other data services over mobile networks, is already changing the way people across the globe access the Internet. It promises to drive even stronger economic growth than mobile telephony alone and to fundamentally change the way in which we live, learn, work, and collaborate. This, in turn, is driving seismic shifts across the communications and computing industries. Perhaps most importantly, it provides unprecedented opportunities to empower individuals across all socioeconomic classes.

Not only has MBB emerged over the past decade to meaningfully extend the reach of the Internet, it has actually become the primary method of access for people around the world. To ensure the ongoing success of MBB and its economic and societal benefits, governments and other stakeholders around the world have an important role in ensuring the availability of the tools and incentives that are needed to spur innovation, new technologies, and new products.

Spectrum is crucial for mobile communications. Its allocation is a key area where cooperation between governments and industry is critical. Although the latest MBB technologies use spectrum much more efficiently than their predecessors, they are approaching the theoretical limits of spectral efficiency. This, combined with the phenomenal growth in MBB, is resulting in a new challenge to find additional spectrum to support the tremendous growth in data usage. The benefits of MBB depend upon the availability of sufficient and appropriate spectrum that is harmonised to the greatest extent possible across borders. Industry must continue to innovate and find more effective ways to utilize spectrum while governments need to allocate and assign spectrum to the highest-value use, such as for commercial MBB. Although different areas, such as across metropolitan, rural and remote areas, may have different demand requirements, they all benefit from increased MBB connectivity

For spectrum to be used as efficiently as possible, standardized technologies must be developed that strengthen connectivity, boost speed, and ensure reliability. In fashioning a spectrum policy, governments are encouraged to create an environment that fosters investment and research and development (R&D) to enable the development and standardization of new innovations such as 5G and the Internet of Things (IoT).

As the *Draft Radio Spectrum Five Year Outlook 2017-2021* states in the section on *International spectrum allocations* that:

- "RSM will work in the replanning of the additional IMT allocations in the C-band (3.4 – 3.6 GHz). RSM will engage in the international regulatory developments in the L-band (1427-

1518 MHz) and the UHF 600 MHz bands in order to assess future options for the New Zealand market" and

- "RSM will review the feasibility of additional spectrum for IMT carriers subject to international harmonisation outcomes, in the L, S and C bands"

Qualcomm supports these action points and is pleased to provide RSM with updates on these bands as follows.

L-band

Qualcomm believes that the 1427-1518 MHz band, also known as the L-band, will be an important resource to meet future mobile broadband (MBB) demand. As MBB demand continues to grow, administrations are seeking additional spectrum bands that can be used to increase capacity and enhance the user experience. Qualcomm considers the L-band to be an ideal candidate for MBB. This position is supported internationally, as this band was identified on a worldwide basis during the International Telecommunication Union (ITU) World Radiocommunication Conference in 2015 (WRC-15).

Notably, developments have already taken place in other regions to designate a portion of the L-band, specifically 1452-1492 MHz, for supplemental downlink (SDL). For example, in November 2013, a European Conference of Postal and Telecommunications Administrations (CEPT) Electronic Communications Committee (ECC) decision was approved on the "harmonised use of the frequency band 1452-1492 MHz for Mobile/Fixed Communications Network Supplemental Downlink (MFCN SDL)" resolving that the CEPT administrations should designate the frequency band 1452-1492 MHz for SDL.[1] This decision was approved with significant support, with 25 administrations indicating that they will implement the ECC Decision. With that, 3GPP has standardized the 1452-1492 MHz for SDL, as band 32, ensuring that there will be commercial devices available when the networks are deployed. Other regional groups are looking at developing common Recommendations to use SDL for the full L-band i.e., 1427 – 1518 MHz. In September 2016, at the last meeting of the Asia-Pacific Telecommunity (APT) Wireless Group (AWG), it was agreed to invite further views on the use of the L-band, and develop a report "To provide technical and regulatory considerations on development of the frequency arrangement(s) in the band 1 427 – 1 518 MHz and possible harmonized frequency arrangement(s) for IMT systems in the band." Discussions are expected to continue during its next meeting planned for March 2017 (AWG21) and the final report is scheduled for completion later in 2017 (AWG-22). Similarly, the Inter-American Telecommunication Commission (CITEL) Consultative Committee II: Radiocommunications (PCC.II) held discussions on a common Recommendation during its meeting in November 2016. ITU-R Working Party 5D (WP 5D), responsible for IMT systems, is discussing harmonizing 90 MHz i.e., 1427 – 1517 MHz, for SDL.

A number of countries have already assigned or are looking at assigning the L-Band for mobile services. In Europe, the 1452-1492 MHz block has been auctioned for SDL in Germany and Italy, as well as traded in the secondary spectrum market in the United Kingdom (UK) for the same use.

[1] ECC/DEC. (13)03 on the "Harmonised use of the Frequency Band 1452-1492 MHz for Mobile/Fixed Communications Networks Supplemental Downlink (MFCN SDL)," available at http://www.erodocdb.dk/docs/doc98/official/pdf/eccdec1303.pdf.

Other European regulators in Cyprus, France, Ireland, and Slovenia are consulting on auctioning the band.

Currently, most parts of the L-band are not heavily used in many countries, and could be released for mobile services in a relatively short timeframe. There is strong support for this band worldwide, so initial assignments in Europe are expected to be followed in other countries, empowering the L-band ecosystem. In this regard, a report developed for the GSM Association (GSMA) on the L-band shows that the initial 40 MHz (i.e., 1452 – 1492 MHz) could be in commercial use in Europe and Latin America in 2018 and in Africa and Asia-Pacific in 2020. [2] The surrounding 50 MHz could be commercially available in many countries by 2025. Band 32 has already been standardized by 3GPP, and smartphones and routers are being produced by HTC, Sony and ZTE[3]. With ongoing efforts in international and regional bodies, it is timely for national regulators to proceed with the identification of the 1.5 GHz band for IMT and the assignment of spectrum.

C-band

With respect to the 3.6 GHz band, there has been considerable operator interest in, as well as deployment of MBB services, in countries around the world, including the Asia-Pacific region (e.g., China, Japan, Korea, Philippines) as well as North America, Europe, and Africa. As noted in the discussion paper, 3GPP has developed band plans conducive to deployment of TDD LTE in the 3400-3600 MHz and 3600-3800 MHz bands (bands 42 and 43, respectively), and is considering the definition of a new band covering the 3550-3700 MHz band for use primarily in the United States.

Further, a number of governments have recently emphasized the use of the broader 3.6 GHz band for MBB services, as well as particular subsets of the band. The European Commission (EC) has identified 3400-3600 MHz and 3600-3800 MHz for MBB applications, and the EC's Radio Spectrum Policy Group issued a consultation earlier this year in which they promoted the 3400-3800 MHz band for early 5G deployments.[4] Japan has had an identification for International Mobile Telecommunications (IMT) services in the 3400-3600 MHz band for nearly 10 years, and in 2015 assigned spectrum in this band to mobile operators for MBB services. In the United States, a major proceeding led to the development of arrangements for MBB services in the 3550-3700 MHz band.[5]

At the ITU there has been considerable discussion of the 3400-3700 MHz band with respect to IMT, with the 3400-3600 MHz band identified for IMT in Regions 1 and 2, as well as in 12 countries in Region 3 (entirely or in part). Further, four Region 2 countries identified the 3600-3700 MHz band for IMT.

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[2] Plum Consulting, "Global momentum and economic impact of the 1.4/1.5 GHz band (L-band) for IMT," (2015), available at http://www.gsma.com/spectrum/wp-content/uploads/2015/10/1-4-1-5GHz-L-band-for-IMT-OCTOBER-2015.pdf.

[3] GSA GAMBoD database at http://gsacom.com/gambod/

[4] See EC Decision 2008/411/EC, available at www.erodocdb.dk/Docs/doc98/official/pdf/ECCDEC1106.PDF and "DRAFT RSPG Opinion on spectrum related aspects for next-generation wireless systems (5G)," (June 8, 2016), available at https://circabc.europa.eu/d/a/workspace/SpacesStore/1a40dd19-c8a8-4ed0-bc9c-6cc5a7755f7d/RSPG16-031Final_Opinion_5G_for_public_consultation.pdf.

[5] Federal Communications Commission, "Report and Order and Second Further Notice of Proposed Rulemaking, GN Docket No. 12-354," (April 17, 2015), available at https://apps.fcc.gov/edocs_public/attachmatch/FCC-15-47A1.pdf.

With growing international interest a global ecosystem is already developing for the 3.6 GHz band. According to the Global Mobile Suppliers Association (GSA), the 3.6 GHz ecosystem (bands 42 or 43) continues to grow, with 87 user terminals now available. There is a trend of convergence with several devices supporting both TDD and FDD modes.[6]

The 3400-3700 GHz frequency range can benefit from commonality of equipment, which is critical due to the number of bands that can be supported in mobile handsets. Global standards have already been developed and equipment already exists to support operation throughout the 3400-3800 MHz range. This band offers a large amount of contiguous spectrum giving the opportunity to deploy channels with wide bandwidth, ideal for 4G and 5G networks.

Sector Developments (Mobile Broadband)

Qualcomm's vision for 5G encompasses; enhanced-Mobile Broadband (eMBB), low latency mission critical services, and the Internet of things. Qualcomm has been driving 5G standards and industry development for many years, collaborating with industry leaders, and spearheading critical research. Furthermore, it is becoming clear that initial 5G deployments will be earlier than originally envisioned. In Qualcomm's response to RSM's Five Year Spectrum Outlook we have, therefore, decided to focus this part of our input on developments and initiatives related to 5G.

Now that 3GPP 5G standardization efforts to develop a global specification called 5G New Radio (5G NR) are well underway, Qualcomm is actively contributing our 5G designs to drive and accelerate this standard. Making 5G NR a reality is incredibly complex. 5G NR must meet an expanding and radically diverse set of connectivity requirements that will not only interconnect people, but also interconnect and control machines, objects, and devices across a wide range of industries and services. This unified air interface needs to be flexible and nimble at applying the right techniques, spectrum and bandwidth to match the needs of each application, and to support efficient multiplexing for future services and device types.

5G NR also needs to get the most out of every bit of spectrum and across a wide array of available spectrum regulatory paradigms and bands — from low bands below 1 GHz, to mid bands from 1 GHz to 6 GHz, to high bands known as millimeter-wave, utilizing exclusive, shared and class licensing schemes.

Qualcomm has developed advanced 5G NR prototype systems to test, demonstrate and trial our 5G inventions. We are planning for wide-scale 5G deployments based on standard-compliant 3GPP NR infrastructure and devices starting in 2019. For further information on making 5G NR a reality, please refer to this recently released Qualcomm whitepaper: https://www.qualcomm.com/documents/whitepaper-making-5g-nr-reality.

Qualcomm has also recently announced its first 5G modem, the Qualcomm®Snapdragon™ X50, to support early 5G millimeter-wave (mmWave) trials and deployments.[7] Importantly, the X50 modem

[6] GSA, "LTE Ecosystem: 6,504 devices announced," (October 13, 2016), available at http://gsacom.com/download.php?id=3983.

[7] https://www.qualcomm.com/news/snapdragon/2016/10/17/meet-snapdragon-x50-qualcomms-first-5g-modem

is built from the ground up for mobility. Years of research and development have allowed Qualcomm to invent technologies to overcome mmWave's limitations, such as 802.11ad which has been commercialized at 60 GHz. Instead of using only a handful of antennas (as with 4G), the Snapdragon X50 5G modem relies on multi-element antenna arrays. The antennas are designed to work together intelligently, using beamforming and beam tracking technologies, extending mmWave's mobility and reach to non-line-of-sight scenarios. For example, the Snapdragon X50 5G modem can direct the energy of the mmWave beam, bouncing off obstacles to reach the mmWave 5G small cell with which it is communicating. The Snapdragon X50 5G modem is expected to begin sampling in the second half of 2017, and the first products integrating it are expected to appear throughout 2018.

Qualcomm has been collaborating with a number of mobile network operators and infrastructure vendors on trials to accelerate wide-scale 5G deployments, and several of these collaborations with Ericsson, Verizon, AT&T, KT and SK Telecom have been announced in recent weeks.[8] These trials will be compliant with the 5G NR 3GPP specification, the global 5G standard.

How 5G Technology Will Contribute to the Global Economy

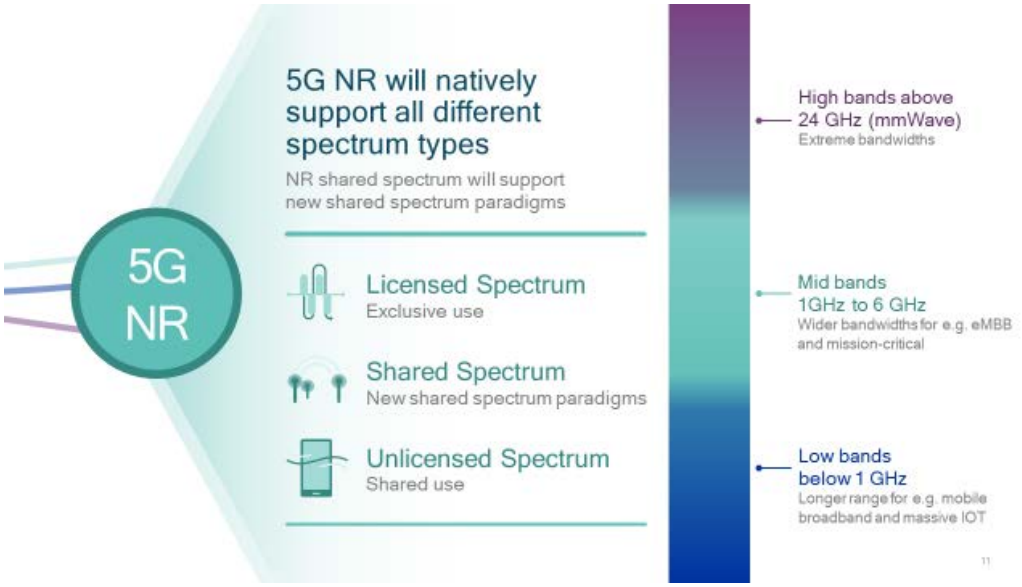
5G will not just be an impressive set of technologies. A recent study based on an international survey of more than 3,500 business decision makers, technology innovators, opinion leaders and technology enthusiasts found that 5G's full economic effect will be realized across the globe by 2035, supporting a wide range of industries and potentially producing up to USD 12 trillion (AUD 15.9 trillion) worth of goods and services.[9] The study also revealed that the 5G value chain (OEMs, operators, content creators, app developers and consumers) could alone generate up to USD 3.5 trillion (AUD 4.6 trillion) in overall aggregate revenue by 2035 and support up to 22 million jobs. The 5G value chain is expected to invest an average of USD 200 billion (AUD 265 billion) annually to continue to expand and strengthen the 5G technology base, and the estimated contribution of 5G to real global GDP between 2020 and 2035 will be equivalent to an economy the size of India.

5G Spectrum

In addition to supporting a wide range of services and devices, 5G will make the best use of a wide array of spectrum available across regulatory paradigms and spectrum bands. Previous generation networks primarily operated in licensed spectrum bands below 3 GHz. 5G will bring the next level of convergence with support for licensed, shared, and unlicensed spectrum. Moreover, 5G will expand spectrum usage to low-bands below 1 GHz, mid-bands between 1 GHz and 6 GHz, and high bands above 24 GHz, also known as mmWave. Together this will open up bandwidths for extreme data rates and capacity that were previously not usable for wide-area mobile communications.

[8] https://www.qualcomm.com/news/releases/2016/12/19/qualcomm-ericsson-and-sk-telecom-announce-collaboration-5g-nr-trials; https://www.qualcomm.com/news/releases/2017/01/03/qualcomm-ericsson-and-att-announce-collaboration-5g-new-radio-trials.

[9] IHS Economics and IHS Technology, *The 5G economy: How 5G technology will contribute to the global economy* (January 2017), available at https://www.qualcomm.com/documents/ihs-5g-economic-impact-study



Qualcomm is pioneering spectrum sharing technologies today with various efforts including LTE Unlicensed, Licensed-Assisted Access, LTE Wi-Fi Link Aggregation, Licensed Shared Access, among others. 5G will be built to natively support and advance these technologies as spectrum sharing becomes increasingly important to meeting tomorrow's connectivity needs for faster data rates and increased network capacity by aggregating unlicensed spectrum opportunistically, but also to enable new deployment models, such as enterprise mobile broadband or private IoT networks. Qualcomm is inventing technologies to deliver robust mobile broadband communications at mmWave spectrum bands with our 5G mmWave prototype system, in addition to the 802.11ad Wi-Fi technology that has already been commercialized at 60 GHz.

RSM is encouraged to further its preparations for the increased spectrum needs of New Zealand mobile network operators and users. More specifically, Qualcomm encourages RSM to advance its 5G spectrum policy via consultative process and to include a roadmap with specific frequency bands and timeframes for spectrum release, taking into account the developments above on global 3GPP 5G standardization as well as other technology leading nations' plans to roll out 5G commercial networks in the near term. As discussed, initial 5G network deployments will be earlier than originally envisioned and it is necessary for RSM to prepare its spectrum policy and plans now to support network rollouts over the next few years. In New Zealand, we see the 3.6 GHz and mmWave bands as the leading candidates for licensed 5G operations in the near term and encourage RSM to set timeframes for spectrum planning and release.

We expect 5G technologies to leverage the strengths of each spectrum band in which they are deployed, and we encourage RSM to continue to engage in international harmonization activities. As noted in the Draft Radio Spectrum Five Year Outlook 2017-2021, the 2019 World Radiocommunication Conference (WRC-19) is expected to take decisions on the identification and harmonization of additional spectrum for 5G. However other countries are already moving forward with planning of frequency bands that can be used for 5G, and trials are expected as early as this year. Thus RSM also does not need to await the outcomes of the next WRC-19, provided it can leverage the standardization developments and ecosystem developments in other technology

leading nations around the world. Hence, Qualcomm supports the work plan action point proposed in the "RSM will participate in the ITU studies (Working Party 5D) related to IMT-2020 (5G) leading to the spectrum allocation decisions expected at WRC-19"

Summary

Mobile devices, technologies, and markets are evolving at an extremely rapid pace, and at the same time the demand for services is increasing which is placing increasing burdens on mobile networks. A combination of increasing the efficiency of existing assets (migrating to more advanced and efficient technologies), employing more resources such as new spectrum and small cells, as well as adopting new ways of acquiring, deploying, operating and managing these resources (e.g. WiFi offload) will be required to meet the ever increasing demand for mobile services.

RSM should continue to monitor national and international developments to ensure that it has the most up-to-date information in order to make timely and robust decisions in relation to the planning, allocation and release of radio spectrum.

Qualcomm believes that there is a continuing need for a close partnership between industry and Government to identify spectrum requirements and develop a spectrum policy roadmap that includes mid and long-term arrangements to meet those requirements, especially to enable the development of 5G. As part of that process, Qualcomm appreciates that, the 5yr Spectrum Outlook Consultation will inform the Government and wider industry about the supply and demand for spectrum resources over the next five years.

The strong international interest and support for use of the 1.5 GHz and 3.6 GHz bands for MBB services make clear that these bands are very likely to play important roles in the development of MBB and 5G services. Demand for MBB services shows no signs of slowing, and there is growing demand for services related to the Internet of Things and enhanced MBB and mission critical services that 5G will make possible. One of the most important inputs that operators will require in order to meet user demands is additional spectrum, including in these two key bands, and Qualcomm encourages RSM to continue its consultative efforts with industry to ensure that they are available in timely fashion.

Should you have any questions or comments on this submission, please do not hesitate to contact me at +852 6901 0087 (mobile) or aorange@qualcomm.com.

Sincerely

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