August 11, 2017

Australian Communications and Media Authority
PO Box 78
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Australia

Qualcomm Incorporated (Qualcomm) welcomes the opportunity to provide input to the Australian Communications and Media Authority (ACMA) on the *Future use of the 3.6 GHz band—Options paper* ("Options paper").

Qualcomm is a world leader in 3G, 4G, and the development of 5G and other advanced wireless technologies. For more than 30 years, Qualcomm's 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 powers many wireless devices commercially available today in Australia and around the world. We are a recognized world leader in the research and development of advanced wireless technologies and continue to bring technology enhancements to market. Since our founding, Qualcomm's philosophy has been to enable many other companies in the wireless value chain to succeed. Today, we license nearly our entire patent portfolio to more than 300 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 whose ultimate beneficiaries are consumers.

In this response, Qualcomm provides updates on 5G, the progress of 5G standardization and consideration of 5G spectrum policy issues, before expressing strong support for the ACMA's proposal to re-farm the 3.6 GHz band as expeditiously as possible and in accordance with ACMA's option 3c to achieve its highest value use.

5G Overview

Qualcomm's vision for 5G is a unifying connectivity fabric that will expand the value of mobile networks to connect new industries and devices, empower new services, enable new deployments, utilize new spectrum bands and types of access, open up new business models, and bring new levels of cost savings and energy efficiency. 5G will bring a new kind of network, supporting a vast diversity of devices with unprecedented scale, speed and complexity. That network will change the way we work and the way we live. The world around us – our homes, cars, cities, manufacturing, and healthcare – will become more intelligent, automated and interconnected. Entire industries will change and emerge as data speeds and latency rise considerably and data costs come way down. Every part of our lives will benefit from the steady flow of critical information gathered by billions of intelligent, connected sensors.

Moreover, 5G will be introduced into a multi-connectivity world which will help to enable a seamless and phased 5G introduction that fully takes advantage of the historic and ongoing 4G, 3G and Wi-Fi

investments with 5G, 4G, 3G, Wi-Fi multimode devices. Qualcomm has been investing in 5G technology innovations for many years, accelerating the path to 5G by leading the research and standardization, as well as creating best-in-class prototypes and testbeds that allow us to work closely with ecosystem partners on impactful 5G trials.

5G will make mobile even more essential than it is today. In 2035 when 5G's full economic benefit should be realized across the globe, a broad range of industries – from retail to education, transportation to entertainment, and everything in between – could produce up to $12 trillion worth of goods and services enabled by 5G.[1] The 5G value chain alone is estimated to generate up to $3.5 trillion in revenue in 2035, and support up to 22 million jobs.

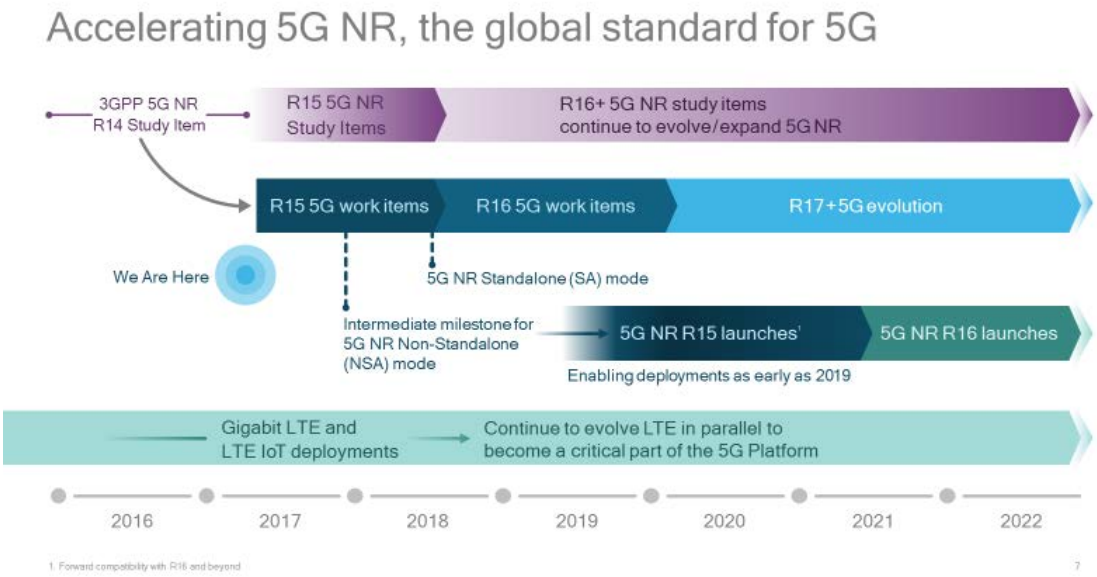
Importantly, 5G is a platform for future innovation. When defining 4G LTE in 2004, technology innovators such as Qualcomm could not at the time predict the full potential of the technology until smartphones, then a new class of devices, were released to the mass market and became so popular. 5G will be similar. It is hard to predict all the new types of services 5G will enable, as it is designed to be a robust, future-proof platform that will unlock new values. We have yet to imagine all the ways that we can use the data, connectivity and computing capability that will become available, put that to work proactively and, as our devices get smarter and smarter, even let the devices act on our behalf.

5G will be driven by heterogeneous services with vastly different requirements – from very low energy sensors, wearables and new form factors, to new mission critical applications with high reliability and low latency (e.g., smart city and critical infrastructure, medical and emergency response, sensing and remote control), to very high data rate backhaul and access transmissions across wide bandwidths for ultra-high capacity broadband. The goal is for 5G to be a new platform with the scalability and adaptability to cost efficiently support new wireless applications, services, and deployment models for the period 2019-2030 and beyond.

5G Standardization

In addition to the work of the ITU on International Mobile Telecommunication beyond 2020 (IMT-2020), the 3rd Generation Partnership Project (3GPP) has been working towards the first specification for a new wireless air interface, 5G New Radio or 5G NR, known as Release 15. Notably, with the support of Qualcomm, Telstra, and many other wireless carriers and vendors around the world, the 3GPP RAN Plenary, at their March 2017 meeting in Dubrovnik Croatia, accelerated the timeline for the completion of the 5G NR global standard. By introducing an intermediate milestone for completion of the standardization of 5G NR "Non-Standalone mode," commercial launches of the 5G NR global standard will be enabled as early as 2019. "Non-Standalone mode" utilizes the existing LTE network as an anchor for mobility management and coverage while adding a new 5G radio access carrier. Forward compatibility is a key design principle for the standardization of 5G NR and will enable in-band introduction of new capabilities and features in subsequent releases critical to enabling yet to be identified industries and use cases. Qualcomm is working actively to enable large scale trials and commercial deployments starting in 2019 based on the 5G NR global standard.

[1] 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



5G Spectrum

To bring 5G to fruition, it is important to get the most out of every bit of spectrum across a wide array of spectrum bands and spectrum regulatory paradigms. 5G will utilize a range of spectrum bands — from low bands such as 600 MHz, to mid bands such as 3.6 GHz, to high bands such as 28 GHz, 39 GHz, and other millimeter wave (mmWave) bands. It will also utilize all spectrum types from licensed, to shared, and unlicensed spectrum.[2]

Indeed, the mobile industry continues to prepare for a massive and continuous increase in mobile data traffic growth due to: greater numbers of more capable LTE smartphones; larger file downloads and streaming driven by an increasing demand for video content; increasing numbers of connected devices including those for the Internet of Things (IoT); and the impending deployment of 5G networks. While increasing the efficiency of existing assets, employing more resources in the form of small cells and spectrum, and adopting radically different ways of acquiring, deploying, operating, and managing these resources are all important, additional spectrum will continue to be essential to supporting increasing numbers of connected devices, growth in demand for mobile broadband (MBB), and the advent of new 5G services.

Whenever possible, Qualcomm supports the assignment of exclusive licensed spectrum for mobile services on a primary basis. However, we understand that this approach is not an option in every country for every band for a variety of reasons. In particular, where there is a range of incumbent users and differing services, there can be unique challenges and opportunities. As such, Qualcomm has developed a spectrum policy that embraces licensed, shared, and unlicensed regimes, and has invested heavily in research and development to drive innovation in new spectrum utilization methods. This policy enables the best possible approach to spectrum usage in each market.

Progressing the Re-farm of Australia's 3.6 GHz band

[2] See "Discussing Spectrum on Capitol Hill," Qualcomm Blog, https://www.qualcomm.com/news/onq/2017/07/20/discussing-5g-spectrum-capitol-hill

Qualcomm strongly supports the ACMA's proposal to re-farm the 3575-3700 MHz band to achieve its highest-value use. We also agree with the ACMA's assessment that wide-area mobile broadband services in the band would be beneficial and increase economic welfare and downstream societal benefits in metropolitan and regional areas of Australia. Re-farming will help to provide certainty to all stakeholders regarding the availability of spectrum, laying a stronger foundation for business planning and investment decisions.

Due to the proximity to other mobile bands and the relatively larger bandwidths available, there is increasing interest and support for accessing the 3.6 GHz band for mobile, either 5G or LTE, in many countries around the world. As the ACMA notes, 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), as well as a new band covering the 3550-3700 MHz band for use primarily in the United States (Band 48). These bands offer a large amount of contiguous spectrum thereby providing the opportunity to support wider carriers. Consequently, harmonization of the 3400 – 3800 MHz bands, or portions thereof, is increasing across the globe and these bands will be instrumental to 5G early deployments in the coming years.

- China: In June 2017, China's Ministry of Industry & Information Technology (MIIT) issued a consultation seeking comment on plans to deploy 5G in the 3.4 to 3.6 GHz and 4.8 to 5 GHz bands.[3]
- Japan: In July 2017, Japan's Ministry of Internal Affairs and Communications (MIC) issued a public consultation relating to 5G spectrum, identifying up to 500 MHz across the 3.6-4.2 GHz and 4.4-4.9 GHz ranges. MIC plans to issue the final technical rules, including the precise frequencies, by mid-2018. 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. Trials in the 3.6-4.2 GHz band are already underway in Japan.[4]
- Korea: Korean regulators are planning to allocate spectrum in the 3400 -3700 MHz range starting in 2018.
- Singapore: In May 2017, the Infocomm Media Development Authority (IMDA) issued a public consultation on spectrum for 5G.[5] The consultation sought comment on a number of spectrum bands between 1 and 6 GHz, as well as millimeter Wave and low-band spectrum, noting that 5G will require spectrum in a range of frequency bands.
- Hong Kong: In March 2017, the Office of the Communications Authority (OFCA) issued a work plan addressing spectrum for 5G.[6] The plan includes a planned public consultation in the latter half of 2017 on reassigning the entire 3400 – 3700 MHz band to mobile services starting in 2020.

[3] http://zmhd.miit.gov.cn:8080/opinion/noticedetail.do?method=notice_detail_show&noticeid=1778.
[4] GSA, "The Future of IMT in the 3300-4200 MHz Frequency Range," (June 2017), p. 11, available at https://gsacom.com/paper/future-imt-3300-4200-mhz-frequency-range/.
[5] IMDA, "5G mobile services and networks," (May 23, 2017), available at https://www.imda.gov.sg/~/media/imda/files/inner/pcdg/consultations/consultation%20paper/public%20consultation%20on%205g%20mobile%20services%20and%20networks/5g-public-consultation.pdf.
[6] OFCA, "The Communications Authority's Work Plan for Making Available Additional Radio Spectrum to Meet the Demand of Public Mobile Services Towards 2020 and Beyond," available at http://www.coms-auth.hk/en/media_focus/press_releases/index_id_1423.html

- United States: In 2015, a major FCC proceeding led to the development of arrangements for MBB services in the 3550-3700 MHz band based on a three-tiered spectrum sharing regime.[7] In early August 2017, the FCC released a Notice of Inquiry also targeting the 3700 - 4200 MHz band longer term.
- Arab States: The Arab Spectrum Management Group in 2017 issued a questionnaire seeking input on the current use of the 3.4-3.8 GHz band, potentially to support consideration of the band for 5G.[8]
- Americas: Countries in the Americas are targeting 3.4 – 3.7 GHz and, at the June 2017 meeting of CITEL PCC.II, a regional recommendation of frequency arrangements for the 3.3 – 3.7 GHz range was approved.[9]
- Europe: In 2016, the European Commission (EC) published its action plan, targeting 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 European Union (EU) by 2025.[10] In June 2016, the ECC established a new Work Item and invited ECC PT1 to assess the suitability of the harmonized technical conditions of ECC Decision (11)06[11] to 5G. In December 2016, the EC RSCOM (Radio Spectrum Committee) issued a mandate to CEPT to develop harmonized technical conditions for spectrum use in support of the introduction of next-generation (5G) terrestrial wireless systems in the Union and in particular to review by June 2018 the harmonized technical conditions applicable to the 3.4-3.8 GHz ('3.6 GHz') frequency band, as a 5G pioneer band. In parallel, Germany and France have recently signaled in their public consultation their willingness to auction this spectrum for 5G, Ireland's ComReg published an Information Memorandum for the forthcoming award of spectrum rights for use of the 3.4 – 3.8 GHz frequency band, in Italy the telecom regulator has published their proposed auction rule for the 3.6 – 3.8 GHz band, in Spain the regulator has provided information on their refarming activity regarding the 3.6 – 3.8 GHz band and their intention to tender it for MFCN. Further spectrum awards are being planned in the United Kingdom and Sweden in the 2017/2018 timeframe.[12]

At the International Telecommunication Union (ITU), there has been considerable discussion of the 3400-3700 MHz band with respect to International Mobile Telecommunication (IMT), with the 3400-3600 MHz

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[7] 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.

[8] GSA, "The Future of IMT in the 3300-4200 MHz Frequency Range," (June 2017), p. 11, available at https://gsacom.com/paper/future-imt-3300-4200-mhz-frequency-range/.

[9] Recommendation PCC.II/REC. XXX (XXIX-17) Frequency arrangements for the terrestrial component of IMT in the Bands 3300-3400 Mhz, 3400-3600 Mhz and 3600-3700 Mhz, or combinations thereof

[10] European Commission, "5G for Europe: An Action Plan," (September 14, 2016), available at https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document.

[11] ECC Decision (11)06 : "Harmonised frequency arrangements for mobile/fixed communications networks (MFCN) operating in the bands 3400-3600 MHz and 3600-3800 MHz" - http://www.erodocdb.dk/docs/doc98/official/pdf/ECCDec1106.pdf

[12] See, for example, Ofcom (United Kingdom), "Update on 5G spectrum in the UK," (February 8, 2017), available at https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf and PTS (Sweden), "PTS launches Spectrum Plan for 5G tests in Sweden," (March 31, 2017), available at https://www.pts.se/en-GB/News/Radio/2017/PTS-launches-Spectrum-Plan-for-5G-tests-in-Sweden/.

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.

We also note the continuing development of a global ecosystem for 3400 – 3800 MHz equipment. According to the Global Mobile Suppliers Association (GSA), the ecosystem continues to grow, with 118 devices now available for use in the 3400 - 3600 MHz band and 93 devices available in the 3600 - 3800 MHz band.[13] The 3400 - 3800 MHz frequency range (or portions thereof) can benefit from commonality of equipment, which is critical due to the number of bands that can be supported in mobile handsets at cost effective levels.

Timing

Identifying, harmonizing, and auctioning spectrum for future 5G networks is truly a global effort; and an extended re-allocation period such as the seven years proposed for metropolitan and regional areas risks Australia's ability to be positioned as an early beneficiary of leading-edge 5G technologies and services. By moving more quickly, the ACMA would better enable Australia to be a leader in 5G and reap the benefits of additional spectrum availability for MBB services. An accelerated timeline would allow the ACMA to join regulators around the world that are diligently working with stakeholders across industries toward the common goal of making mid-band spectrum (1-6 GHz) available for 5G. As mentioned above, the 5G NR global standard has been accelerated to enable commercial deployments as early as 2019.

Based on the above mentioned international, national interest, band standardization and ecosystem developments, many of the initial 5G commercial deployments and trial networks will be in the 3.6 GHz spectrum. Qualcomm therefore encourages the ACMA to accelerate its re-farming process to ensure the 3400 – 3700 MHz band is available for 5G commercial and trial networks as soon as practicable. This will pave the way for innovation and investment, and facilitate the deployment of more innovative and advanced mobile technology, networks and services in Australia.

Support for Option 3c

Qualcomm supports the assignment of licensed spectrum to the mobile service on an exclusive basis in the 3400 – 3700 MHz band in Australia. In the United States a three-tiered approach has been adopted for this band. This approach was developed to address features of the United States' 3.6 GHz spectrum usage that are specific to the United States. As these features are not evident in the Australian context a similar approach is **not** warranted.

In line with this spectrum policy and consideration of Australia's particular spectrum usage and geography characteristics, Qualcomm supports the ACMA's plan to rearrange the 125 MHz of the 3575 – 3700 MHz band in metropolitan and regional areas in an optimal manner for wide-area MBB deployment. The demand for MBB and 5G services (and greater network capacity) is typically greatest in the metropolitan areas. Thus, Qualcomm agrees with the approach of prioritizing the high-demand areas (and some low-to-medium demand areas) represented by Area 3. Such an approach would enable the deployment of advanced MBB systems and 5G earliest in the metropolitan and regional areas where there are likely to be the most initial users.

[13] GSA, "The Future of IMT in the 3300-4200 MHz Frequency Range," (June 2017), p. 27, available at https://gsacom.com/paper/future-imt-3300-4200-mhz-frequency-range/.

Considering Australia's current and expected future use of the 3.6 GHz band, Qualcomm agrees that in areas where demand is likely to exceed supply, a spectrum licensing approach that maximizes certainty of long-term access to wide-area broadband users will serve users and the market best. Such an approach, combined with a clear plan for relocating incumbent users to other appropriate spectrum to provide certainty for those users, will enable Australia to make the best use of its mid-band spectrum.

Importance of mmWave bands

In addition to mid-bands such as 3.6 GHz, millimeter Wave (mmWave) bands will also be needed to support 5G services. Whereas sub-6 GHz bands currently make available channel widths of up to 20 MHz with the possibility of 100-MHz bandwidths in the future, mmWave bands provide very wide bandwidths to meet the growing demands for high-quality end-user performance and network capacity.[14] With more advanced antenna design and RF processing techniques, the mmWave bands can be mobilized to deliver multi-Gbps peak rates that scale with available channel width and modulation—for extreme mobile broadband use cases. The large bandwidths afforded by mmWave spectrum above 24 GHz allow for delivery of ***mobile*** services at very high data speeds and capacity that cannot currently be achieved with lower band spectrum. The path to even more spectrum is through the expansion into mmWave bands to deliver a vast amount of capacity.

mmWave provides more localized coverage compared to sub 6 GHz, so mobilizing mmWave requires simultaneous use of lower spectrum bands to ensure wide area coverage and a seamless user experience. This is accomplished via multi-connectivity where 5G multimode devices simultaneously connect both to the lower bands for wide-area coverage and the higher mmWave bands for additional bandwidth and capacity boost.

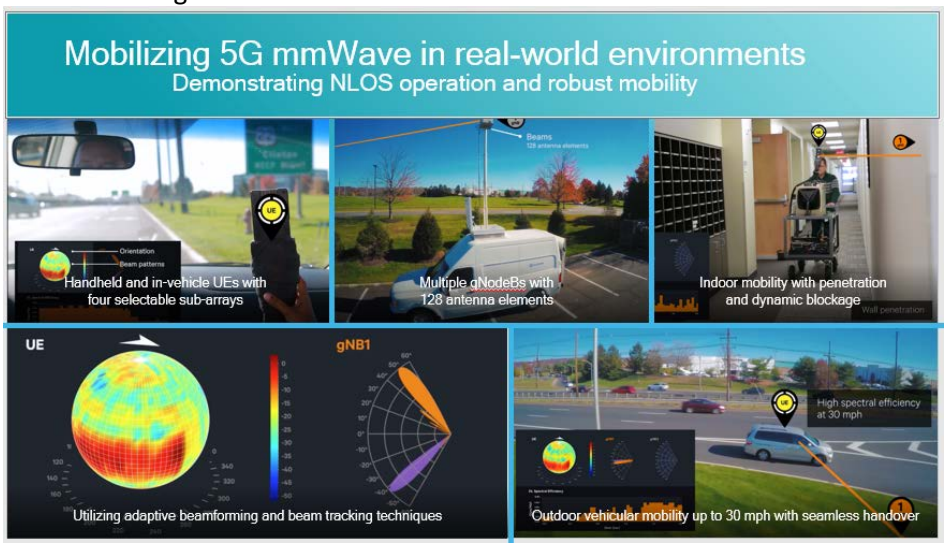
Qualcomm is inventing technologies to deliver robust mobile broadband communications at mmWave spectrum bands. We recently announced our first 5G modem, the Qualcomm Snapdragon X50, to support both sub-6 GHz and multi-band mmWave Spectrum.[15] These new modems are designed to provide a unified 5G design for all major spectrum types and bands while addressing a wide range of use cases and deployment scenarios. The Snapdragon X50 5G modem family is engineered to provide wider bandwidths and extreme speeds for enhanced mobile broadband. Additionally, the modem solutions are designed to support both Non-Standalone and Standalone (where all control signaling and user data are sent over 5G NR) modes of operation, and are designed to enable the next generation of premium-tier mobile cellular devices, while also aiding operators to execute early 5G trials and deployments. Commercial products integrating 5G NR modems from the Snapdragon X50 family are expected to be available to support the first large-scale 5G NR trials and commercial network launches starting in 2019.

Importantly, the X50 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 instance, the Snapdragon X50 5G modem can direct the

Gabriel Brown, "Exploring the Potential of mmWave for 5G Mobile Access," (June 2016), available at .

[14] https://www.qualcomm.com/news/releases/2017/02/25/qualcomm-expands-industrys-first-announced-5g-modem-family-support-5g-nrmodem.

energy of the mmWave beam, bouncing off obstacles to reach the mmWave 5G small cell with which it is communicating.



Many other administrations and regions have already taken decisions to release mmWave spectrum for 5G. If Australia wishes to maintain its leading position in mobile technology and policy development, including 5G, it should finalize its 5G spectrum policy and planning for these bands, and ensure spectrum is released well in advance to allow commercial deployments as early as 2019.

Summary

Qualcomm welcomes the opportunity to convey our views to the ACMA on the consultation *Future use of the 3.6 GHz band—Options paper*. Qualcomm supports efforts by the ACMA to ensure there is a conducive environment for the development and deployment of 5G technology. We encourage the ACMA to move swiftly to the re-farming stage for the 3.6 GHz band and to progress in accordance with option 3c.

Should you have any questions or comments on this submission, please do not hesitate to contact me at +852 6348 6687 (mobile) or juliewelch@qti.qualcomm.com.

Sincerely,

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Cc: Alex Fernandez, Director of Business Development, Qualcomm International