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26 August 2015

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Dear Ms. Chia,

Qualcomm Incorporated, on behalf of itself and its subsidiaries (collectively, "Qualcomm") appreciates the opportunity to provide further input to the IDA on its *Second Consultation on Proposed Framework for the Allocation of Spectrum for International Mobile Telecommunications ("IMT") and IMT-Advanced Services and for the Enhancement of Competition in the Mobile Market* ("the Consultation Paper"). Qualcomm is a world leader in 3G, 4G and next-generation wireless technologies. Our ideas and inventions have driven the evolution of wireless communications, connecting people more closely to information, entertainment and each other. Qualcomm Technologies, Inc., a wholly-owned subsidiary of Qualcomm Incorporated, is the world's largest fabless semiconductor producer and the largest provider of wireless chipset and software technology, which powers a large portion of the wireless devices commercially available today. Qualcomm is a recognized world leader in advanced wireless technologies and continues to bring enhancements to market that increase network operators' capacity and performance.

As noted in the Consultation Paper, global mobile data consumption is growing at a rapid pace, and while the projections vary, all indications point to this growth continuing unabated. For example, GSMA Intelligence predicts that global mobile data traffic will increase 10-fold between 2014 and 2019.[1] The mobile industry is therefore preparing for an increase in mobile data traffic growth that Qualcomm refers to as "The 1000x Data Challenge."[2] Qualcomm is providing the vision and developing solutions to meet this 1000x challenge. The mobile industry's latest wireless technologies and trends offer solutions capable of meeting the 1000x challenge—some of which are already developed—and there is a robust roadmap

[1] "The Mobile Economy" 2015; GSMA Intelligence available at http://www.gsmamobileeconomy.com/GSMA_Global_Mobile_Economy_Report_2015.pdf.
[2] https://www.qualcomm.com/1000x.

for many more. Even with these advances, however, mobile operators will need additional spectrum in the future.

Given the increasing demand for mobile data and video services, and hence the increasing need for spectrum suitable for mobile broadband, Qualcomm believes the IDA's continuing consultation on matters related to IMT and IMT-Advanced spectrum is an important step in determining just how Singapore will meet its future spectrum needs. We encourage the IDA to explore every opportunity to make available spectrum both below and above 1 GHz for IMT and IMT-Advanced use in order to ensure the best possible mobile user experience. Below we present our specific responses to the questions raised in the Consultation Paper.

700 MHz

Views and comments on the proposed allocation of the 700 MHz band together with other suitable bands for mobile services in the next spectrum allocation exercise; and the mechanism to allow the delay of the commencement date of the 700 MHz spectrum right, and correspondingly, the expiry date as well as the spectrum right payment due date, in the event of a delay in the ASO.

Qualcomm strongly supports the IDA's approach to the release of the 700 MHz band. Allocation of this 2 x 45 MHz based on the Asia Pacific Telecommunity agreed FDD band plan enables a highly efficient usage of valuable sub-1 GHz spectrum, maximizes the usable bandwidth, and provides inherent guardband to facilitate coexistence with services in adjacent bands.[3] We are also pleased to see acceleration of the target date for access to 2018. This is a reasonable and achievable target for Singapore (as well as a number of neighboring countries) and still allows a period of time for the government and industry to complete the analog to digital broadcast transition. It has been a number of years since these frequencies were identified for IMT at the ITU World Radiocommunication Conference in 2007 and, subsequently, harmonized at a regional level and standardized within the standards development organizations. Qualcomm and other chipset, device and infrastructure manufacturers now provide commercial equipment supporting this band, hence, the device ecosystem is robust and growing. Leading handset manufacturers, including Acer, Apple, Asus, HTC, Huawei, LG, Motorola, Samsung, Sony and ZTE have all incorporated APT700 in their product offerings and a total of 139 devices including handsets, tablets and routers are currently available.[4]

Sub-1 GHz spectrum is critical for providing coverage to rural areas and within buildings due to the favorable propagation of radio signals in this frequency range. Network operators need access to sufficient spectrum in both lower, below approximately 1 GHz, and higher frequency bands to meet coverage and capacity obligations, penetrate buildings particularly in dense urban environments, and provide users a seamless mobile experience. IDA's proposal to release 2 x 45 MHz of 700 MHz spectrum will help network operators to meet this essential need for lower band spectrum.

Qualcomm firmly believes *commercial* mobile broadband is the highest value use of the 700 MHz spectrum and through such use a country can extract significant economic benefit. For example, the Boston Consulting Group undertook study of the economic benefits of the 700 MHz band for Asia and found that harmonization with APT700 for mobile broadband could deliver up to USD 1 trillion

[3] GSA Evolution to LTE report, 21 July 2015.
[4] GSA GAMBOD database, August 2015.

incremental increase in GDP, increase in Government revenues of USD 215 billion, and 2.7 million additional jobs by 2020.[5]

We continue to believe that a market based multi-band allocation process e.g., auction, as proposed by the IDA, will allow operators to obtain spectrum across the frequency bands that they believe will best suit their business and technology plans. With demand for mobile broadband services exploding and continued development of new technologies to enhance performance and deliver the best possible user experience, providing operators with a high degree of certainty regarding spectrum planning will be instrumental in facilitating new and innovative services in Singapore.

800 MHz

The proposed 800 MHz band plan based on the 3GPP band 26, or a combination of 3GPP band 27 and band 5 (excluding the EGSM band), including views on the possible phased approach and timeline to migrate existing users of the band.

Qualcomm believes that spectrum in the 800 MHz band should also be considered for inclusion in the next spectrum allocation exercise. This is a key band for mobile operations around the world and has been for many years. The re-farming of the 850 MHz band, as the IDA has proposed, would add spectrum for IMT/IMT-Advanced services which, particularly when combined with proposed spectrum allocations in the 700 MHz, 900 MHz and above 1 GHz bands, provides attractive and useful options for operators seeking to improve their mobile broadband spectrum resources. Propagation characteristics are also very favorable. While this band has traditionally been used for CDMA2000 and WCDMA/HSPA technology deployments (e.g., across the Americas, China, India, Japan, Korea, Australia, Indonesia, Thailand), the trend is now to deploy LTE technology in the 850 MHz band, and many operators are migrating their networks accordingly. Indonesia and Malaysia are two examples of countries within ASEAN who have already licensed 850 MHz spectrum to allow for LTE deployments. In Indonesia in 2014, the government issued a decree confirming the ability for operators of CDMA2000 networks in 850 MHz to migrate to their technology of choice,[6] and LTE 850 has been commercially launched. In addition, Malaysia and Indonesia have aligned the interface between their 850 MHz and 900 MHz frequency assignments around the 880 MHz boundary to minimize cross border interference issues.[7] Given the scarcity of suitable spectrum, in particular below 1 GHz, we believe governments and operators should make the most efficient and effective use of all suitable spectrum resources. The extensive mobile deployments in this band will ensure the LTE 850 MHz device ecosystems are strong. Qualcomm also agrees with the IDA's intent to work closely with users of trunked radio and short-range devices (SRDs) in order to minimize the impact on their services during the re-farming process. We support the idea of transitioning SRD users from 866 – 869 MHz into the 900 MHz band where plans are already underway to expand the SRD frequencies, and to encourage trunked radio users to invest in more spectrally efficient technologies. A well-planned re-farming exercise should result in improved and more efficient services for users of mobile broadband

[5] The Economic Benefits of Early Harmonization of the Digital Dividend Spectrum & the Cost of Fragmentation in Asia, The Boston Consulting Group 2012.

[6] THE REPUBLIC OF INDONESIA MINISTER OF COMMUNICATIONS AND INFORMATICS REGULATION NUMBER 30 OF 2014 CONCERNING ARRANGEMENT OF 800 MHz RADIO FREQUENCY BAND FOR CELLULAR MOBILE NETWORK OPERATIONS.

[7] SKMM SRSP–504: Requirements For Mobile Cellular Systems and International Mobile Telecommunications (IMT) Systems Operating in the Frequency Bands 825 MHz to 835 MHz Paired With 870 MHz to 880 MHz and 880 MHz to 915 MHz Paired With 925 MHz to 960 MHz, Malaysian Communications and Multimedia Commission, 31 January 2013; See also note 6 supra.

services, as well as SRDs and trunked radio. Given the significant benefits that would accrue, it is important that the re-farming exercise be completed as expeditiously as possible and that the 850 MHz spectrum be included in the next spectrum allocation exercise.

Qualcomm agrees with the IDA's suggestion to align with 3GPP Band Class 26 or Band Classes 5 and 27. Both would enable the continued growth of mobile broadband in Singapore, while maximizing the value of the 850 MHz band. As noted in our comments on the previous consultation, there are already commercial deployments using equipment based on Band 26 in Korea, Japan, the United States, and great interest from many other operators and countries. Thus, the prospects for additional use of this arrangement are promising, meaning there is significant potential for regional and international harmonization and the resulting economies of scale. In addition, the combination of Band 5 and Band 27 is also very attractive. While commercial deployments may still be limited, other countries, particularly in the Asia Pacific and Latin American regions, have indicated an interest to use Band 27 for LTE.

900 MHz

IDA would like to seek views and comments on the allocation of the short-term spectrum rights for the EGSM band, including the approach to extend the short-term spectrum right.

Qualcomm continues to believe that the priorities for spectrum planning should be to ensure a high level of certainty regarding when spectrum will be allocated and made available, in what bands and quantities, and that the process for doing so is efficient, transparent and equitable. These factors are crucial to mobile network operators making decisions on their network planning and investments. With respect to the 900 MHz band, we believe that as much of the band as possible should be allocated for commercial mobile broadband services.

The two-stage process proposed by IDA, while providing certainty, may not appeal to operators that plan their spectrum usage in the longer term. As the rationale for the two-stage plan appears to be driven by the high-speed rail (HSR) project mentioned in the Consultation Paper, it would be beneficial to consider whether there is an approach that could meet the needs of the HSR project while also allowing for a single-stage allocation process for spectrum suitable for IMT/IMT-Advanced.

Specifically, we question whether the use of GSM-R for a project expected to begin operations no earlier than 2020 is appropriate. Although stakeholders are considering options for improving the capacity of GSM-R networks, others have begun to not only develop and test, but also deploy IMT-based systems for railway communications. As one example, Alcatel-Lucent's Bell Labs published a paper in 2013 considering the feasibility and challenges of deploying LTE for high-speed railway environments, and concluded that LTE-based systems would not simply replace GSM-R, but improve upon it.[8] Moreover, in July 2015, ZTE announced the launch of its LTE-R broadband network solution, which includes multimedia trunked dispatching, video phones, real-time video surveillance and release of comprehensive passenger information.[9] Huawei has also developed an LTE-based system that has been deployed on at least two

[8] Jaime Calle-Sánchez, Mariano Molina-García, José I. Alonso, and Alfonso Fernández-Durán, "Long Term Evolution in High Speed Railway Environments: Feasibility and Challenges," (2013), *Bell Labs Technical Journal* 18(2), 237–253 (2013).

[9] ZTE, "ZTE Launches New LTE-R Next-Generation Broadband Network Solution for Rail Operators," (July 8, 2015), available at http://wwwen.zte.com.cn/en/press_center/news/201507/t20150708_436190.html.

Chinese rail lines.[10] For the provision of connectivity for onboard passengers, China Mobile has employed an LTE TDD network over a 60-kilometer stretch of high-speed railway.[11] In addition, Alstom and Huawei have developed an LTE-based multi-service, broadband radio system for use by metropolitan heavy-rail (metro) systems that, similar to ZTE's solution, offers a suite of specialized services intended for metro/rail use.[12]

It is worth noting that the subject of broadband communications between trains and tracksides is already under consideration by several international or regional entities. For example, the International Telecommunication Union's (ITU) ITU-R Working Party 5A is conducting studies on train-to-ground communications in high mobility environments, including radio propagation characteristics and other key issues.[13] The International Union of Railways (UIC) and the European Railway Agency (ERA) have also taken steps to advance the development of next-generation railway radiocommunication systems. The UIC has been working toward what is now known as the Future Railway Mobile Communication System (FRMCS) since 2009, and current efforts are being coordinated with the ERA.[14] The ERA and the European Commission expect a decision on the future system by 2018, with deployment to begin by 2022. Finally, China has proposed an Agenda Item for the ITU's 2019 World Radiocommunication Conference "to consider spectrum related matters and possible regulatory actions, so as to support the next generation radiocommunication system between train and tracksides."

An LTE-based technology for railway communication would not necessarily be limited to the 900 MHz spectrum currently used by GSM-R system. While studies are still underway, it is possible that LTE-based systems could be deployed in any of several bands suitable for LTE.

Qualcomm believes that it would be prudent for Singapore (and some of its neighboring countries) to reconsider the use of GSM-R technology for the HSR project, and instead base their decisions for train communications on newer technologies such as LTE. Such an approach would have the dual benefit of providing modern broadband-enabled connectivity for the HSR system and simplifying the process of coordinating and allocating the maximum amount of spectrum for commercial mobile broadband in the 900 MHz band. Indeed this approach may be extended to all of ASEAN.

1.4 GHz

a) The proposed re-allocation of the L-band for wireless broadband in Singapore in the longer term; and b) The allocation of the L-band for trial, temporary use and/or commercial services in the interim period.

Qualcomm strongly supports the IDA's approach to release of the 1.4 GHz band for IMT. We understand that final decisions cannot be made until after WRC-15 given the ongoing developments in the

[10] International Railway Journal, "LTE displays potential in Zhengzhou," (February 11, 2014), available at http://www.railjournal.com/index.php/telecoms/lte-displays-potential-in-zhengzhou.html.
[11] Telecoms.com, "China Mobile brings TD-LTE to high-speed trains," (December 10, 2012), available at http://telecoms.com/54943/china-mobile-brings-td-lte-to-high-speed-trains/.
[12] Railway Technology, "Alstom and Huawei complete first LTE 4G project for metros," (July 1, 2015), available at http://www.railway-technology.com/news/newsalstom-and-huawei-complete-first-lte-4g-project-for-metros-4613420.
[13] See, for example, "Annex 10 to Working Party 5A Chairman's Report (Annex 10 to Document 5A/736-E," (July 17, 2015).
[14] UIC, "The UIC Future Railway Mobile Communication System has officially started," (January 29, 2014), available at http://www.uic.org/com/uic-e-news/383/article/the-uic-future-railway-mobile?page=thickbox_enews.

international and regional communities towards harmonization of L-band for mobile broadband services. The IDA's proposal allows operations, at least on the 1452-1492 MHz portion which has been harmonized within Europe for mobile supplemental downlink, during this interim period for trials, temporary use, and/or commercial services (i.e., on a non-interference and unprotected basis). The IDA also recognizes that the band is largely underutilized and "that it would be suitable to re-allocate the L-band for wireless broadband, which may include SDL, in Singapore eventually, given the international developments on the use of this band." We believe that the 1427-1518 MHz band will be an important resource to meet future mobile broadband demand, and agree that the prudent approach is to align Singapore's plans with the outcomes of WRC-15. It is significant to note that a number of regional groups, including CITEL in the Americas and CEPT in Europe, have agreed upon regional common proposals to the WRC-15 in support of IMT identification of the 1427-1518 MHz band.

TDD bands – 2.3 GHz

Qualcomm supports the long-term allocation of the *entire* 2.3 GHz band for mobile broadband services as soon as is feasible due to the escalating demand for mobile broadband spectrum and the growing 2.3 GHz LTE TDD ecosystem. Of the 59 LTE TDD (or converged FDD and TDD) networks worldwide, 25 are deployed in the 2.3 GHz band, including networks in Australia, China, Hong Kong, India, Indonesia, Sri Lanka and Vanuatu in the Asia-Pacific region.[15] In June 2015, 1,210 devices (or 37.2% of all LTE devices) supported LTE TDD, including 869 devices that support it in the 2.3 GHz band.[16] The 2.3 GHz band is the most widely used of the LTE TDD bands, and Qualcomm expects additional deployments and device choices will be rolled out in the next several years. Allocating the full 2.3 GHz band for mobile broadband services in Singapore would thus allow operators to capitalize on economies of scale with respect to infrastructure and devices.

With respect to IDA's plan to release only 30 MHz of the band, Qualcomm requests that additional information be made available as to the constraints facing the remainder of the band. We note that both Indonesia and Malaysia have licensed or plan to license the full band from 2300-2390 MHz, subject to international coordination requirements, which raises some questions regarding the IDA's proposal to only release 30 MHz.

We encourage the IDA to re-examine the constraints that it believes prevent the allocation of more than 30 MHz in the 2.3 GHz band, and to share the results of this examination with interested stakeholders. Qualcomm expects this band to play an important role in the provision of mobile broadband services, notably in the Asia-Pacific region, and it would be unfortunate if Singapore were not able to take full advantage of the benefits this band offers.

TDD bands – 2.5 GHz

Qualcomm supports the IDA's proposal to allocate 2570-2615 MHz for mobile services in the next spectrum allocation exercise. LTE TDD deployments continue to expand in this band and Qualcomm believes that the allocation of 45 MHz for such services will ensure that Singapore can take advantage of economies of scale for network equipment and handsets, as well as facilitate roaming agreements.

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[15] GSA, "LTE TDD: Global Status," (July 21, 2015), available at http://www.gsacom.com/downloads/pdf/Snapshot_LTE-TDD_extract_GSA_Evolution_to_LTE_report_210715.php4.

[16] Ibid.

Allocating the TDD bands in Singapore will also allow mobile network operators to capitalize on the most current enhancements to LTE-Advanced such as carrier aggregation across LTE FDD and LTE TDD. In June 2015, Vodafone and Ericsson deployed this enhancement which is supported on Qualcomm's Snapdragon 810 processor with X10 LTE and Ericsson's Networks Software 15B release.[17]

3.5 GHz

Qualcomm believes that removing the 3.5 GHz band from consideration during a period of rapidly escalating spectrum demand is likely to result in an unnecessary spectrum crunch in Singapore posing a risk to government plans to increasingly connect residents, businesses and individual devices in the coming years. The 3.5 GHz band is already being used by mobile operators to enable improved mobile broadband services and, as Singapore has seen, robust mobile services are an important enabler of economic growth. We believe the 3.5 GHz band will also be key to the Smart Nation initiative and other efforts to better connect all corners of the economy. As it can take more than 10 years from the time that a frequency band is allocated/identified by a World Radio Conference (WRC) to the time that the band is licensed and used to deliver IMT services, it is critical that decisions on additional mobile identifications in the 'extended' C-band are taken at the next WRC in November 2015. This action is needed now in order to meet the expected mobile data demands in 2020 and beyond.

We are pleased that the IDA will "continue to monitor the international trends and technology developments for the 3.5 GHz band, as well as explore the possibilities for co-existence of mobile technologies and FSS/TVRO systems in this band." Qualcomm encourages the IDA to undertake study of the actual usage of the 'extended' C-band frequencies in Singapore, between 3.4 GHz and approximately 3.7 GHz. Our understanding is that usage of this portion is not as extensive as the 'standard' C-band downlink above 3.7 GHz, and varies widely by country. Thus, we believe possibilities exist for frequency separation or segmentation between portions of the band which can be used for FSS/TVRO and non-overlapping portions of the band which can be used for mobile broadband. For any existing FSS/TVRO operations in the 'extended' C-band, it would be possible to develop a plan to migrate operations to either the 'standard' C-band or other suitable fixed-satellite service allocated bands. A suitable timeframe for this migration could be developed. In addition, small cell technology presents new opportunities for co-existence which can also be further explored. Importantly, these studies can be conducted ***after*** the WRC-15 has taken decisions on additional mobile identifications in the 'extended' C-band range. We strongly encourage the government of Singapore to support additional IMT identifications in the 'extended' C-band at WRC-15 in order to provide a path suitable for Singapore's ongoing development.

To provide a brief update on international trends, portions of the C-band from 3.4 – 3.6 GHz and 3.6 – 3.8 GHz have been standardized within 3GPP as Band Classes 42 and 43, respectively, both for TDD. Commercial networks using Band Class 42 user devices have already been launched in Bahrain, Belgium, Canada, Italy, the Philippines, and Spain.[18] And, in the United Kingdom, commercial networks have been launched using Band Classes 42 and 43 equipment. Plans are also underway in the United States, Japan, and a number of other countries to license portions of the 'extended' C-band. These deployments are all based on LTE TDD technology. In Europe, CEPT's Electronic Communications Committee has released Decision (11)06 on "Harmonised frequency arrangements for mobile/fixed communications networks

[17] http://www.rcrwireless.com/20150623/carriers/vodafone-and-ericsson-launch-fddtdd-carrier-aggregation-tag4

[18] See note 3 supra.

(MFCN) operating in the bands 3400-3600 MHz and 3600-3800 MHz."[19] Thus, it is clear, momentum for LTE TDD technology is firmly taking hold in 3.5 GHz. Carrier aggregation combinations involving Band 42 have already been filed with 3GPP by NTT, China Academy of Telecommunication Technology (CATT) and Huawei.

In addition to these existing and planned deployments, there has been agreement within certain regional groups preparing for WRC-15 to support further IMT identification. The recent CITEL meeting agreed upon a preliminary common proposal for the Americas in support of 3.4-3.6 GHz and CEPT has agreed upon a common proposal in support of 3.4 – 3.8 GHz. Moreover, as was discussed at the recent Asian Pacific Telecommunity WRC preparatory meeting, there remains support from some countries for an IMT identification in 3.4 – 3.7 GHz and these countries are expected to propose this directly to the WRC-15.

Qualcomm believes that small cells – notably in the 3.5 GHz band – are a key component of a holistic approach to meeting the demand for additional mobile broadband capacity. Such cells should be an important element of Singapore's HetNet and Smart Nation Platform, and they are ideal for higher spectrum bands, such as 3.5 GHz. Qualcomm has invested considerable resources in research and development of technology solutions and innovations to address the mobile data spectrum challenge. Small cells are the center piece of our 1000x vision. We believe hyper-dense small cell networks will be needed in all shapes and forms – femtocells, picocells, metrocells, relays and more – and based on all technologies, e.g., 3G, 4G, Wi-Fi. To achieve hyper-densification, small cells will need to be deployed in more of an unplanned/ad-hoc way, much like Wi-Fi. This requires small cells to be plug and play and self-organizing, independently adapting to the changes in the network. Many countries have embraced small cell technology and recognized the benefits in enabling the deployment of small cells for IMT services in the 3.5 GHz band. For example, the United States recently approved rules that will enable the deployment of small cells in portions of the 'extended' C-band.[20] In addition, Japanese operators KDDI, NTT DoCoMo, and Softbank Mobile are planning small cell deployments in the 3.5 GHz band.[21]

Qualcomm highly appreciates the opportunity to provide input to the IDA on this Consultation Paper. Please do not hesitate to contact me (juliewelch@qti.qualcomm.com, mobile: +852 6348 6687) for additional information or more detail on Qualcomm's views relating to these topics.

Sincerely,

Julie Garcia Welch
Senior Director and Head of Government Affairs, Southeast Asia & Pacific
Qualcomm Incorporated

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[19] European Commission Decision 2008/411/EC, available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:144:0077:0081:EN:PDF. In December 2011, CEPT's Electronic Communications Committee released Decision (11)06 on "Harmonised frequency arrangements for mobile/fixed communications networks (MFCN) operating in the bands 3400-3600 MHz and 3600-3800 MHz," available at: http://www.erodocdb.dk/docs/doc98/official/pdf/ECCDec1106.pdf.

[20] FCC, Report and Order and Second Notice of Proposed Rulemaking (GN Docket No. 12-354) (April 21, 2015), available at https://www.fcc.gov/document/citizens-broadband-radio-service-ro.

[21] Cellular News, "Japan's Mobile Operators Gear Up for 3.5 GHz Rollouts," (May 1, 2015), available at http://www.cellular-news.com/story/Reports/67521.php.