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Dear Ms Chia,

Qualcomm Incorporated, on behalf of itself and its subsidiaries (collectively, "Qualcomm") appreciates the opportunity to provide input to the IDA on its *Proposed Regulatory Framework for TV White Space Operations in the VHF/UHF Bands* 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 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 capacity and performance.

Global mobile data traffic has doubled every year for the last few years. While the projections vary, all indications point to this growth continuing unabated. The mobile industry is therefore preparing for a staggering 1000x increase in mobile data traffic growth which Qualcomm refers to as "The 1000x Data Challenge." [1] 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 for many more.

As wireless networks strain to meet the growing demand for mobile broadband services, radiofrequency spectrum availability and access remain critical. There are many enhancements to increase the efficiency of existing spectrum. But meeting an increase of the magnitude of 1000x will unquestionably require more spectrum. As shown in **Figure 1** below, there are three approaches to making new spectrum available:

1) Traditional licensing

[1] http://www.qualcomm.com/solutions/wireless-networks/technologies/1000x-data.

2) Authorized Shared Access (ASA)
3) Unlicensed approach

Each of these approaches has a specific usage scenario. Qualcomm is currently developing product solutions for all three of these approaches.

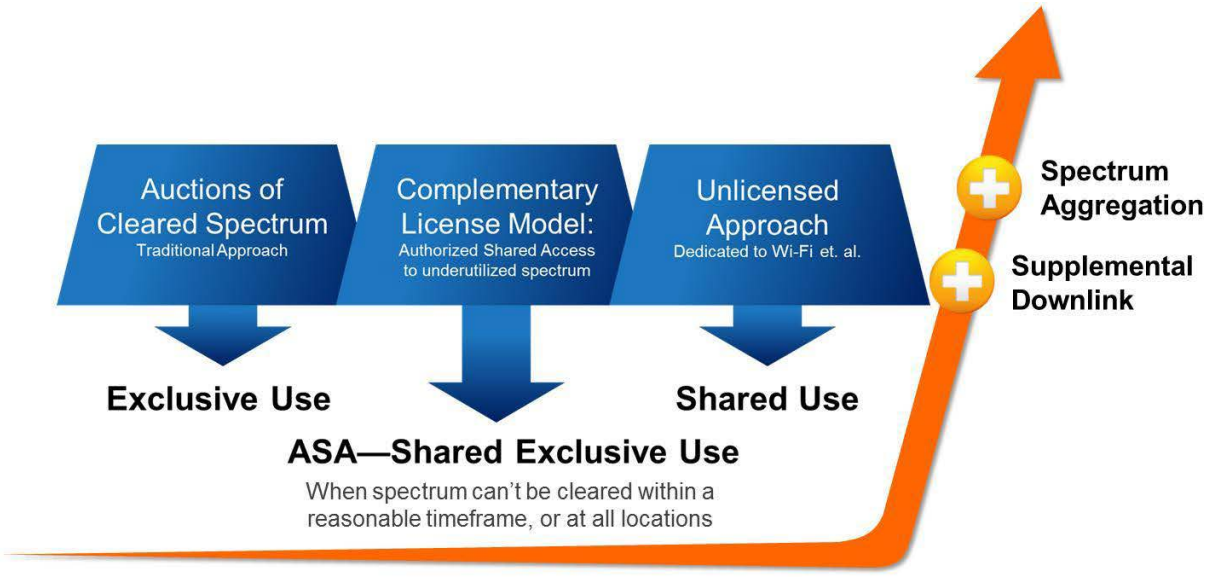

Figure 1 - Sources of new mobile broadband spectrum

Traditionally licensed spectrum gives exclusive rights to the licensee (or licensees) on a nationwide, 24x7 basis. The exclusive use allows planned and orderly deployment, and compatibility with other co-existing and planned services, which results in predictable performance and a quality of service that businesses can monetize and consumers can rely upon, at all times and no matter where they happen to be. Identifying, allocating and clearing this spectrum can be an arduous process. Globally, regulators have demonstrated the effectiveness of this approach. Additional licensed spectrum continues to be the wireless industry's top priority.

In cases when the spectrum cannot be cleared for licensing within a reasonable timeframe by a date certain, or on a nationwide basis, Qualcomm and its partners are proposing a new approach called Authorized Shared Access or ASA (also known as Licensed Shared Access or LSA). ASA applies to bands allocated to governmental entities, which don't use the spectrum 24/7 and/or on a nationwide basis. With ASA, an authorized operator could use the spectrum when and where the government is not using it. ASA has the potential to unlock underutilized spectrum in higher frequency bands for 3G/4G services, in a cost-effective and timely manner. ASA is a binary system—either the governmental incumbent uses the spectrum, or a commercial operator can do so, and in that case, the single authorized operator gets the benefits of being the only entity permitted to use the spectrum. In this manner, ASA also allows predictable Quality of Service (QoS), which is important for consumers.

Globally, Wi-Fi uses unlicensed spectrum in the 2.4 GHz and 5 GHz bands. In this spectrum, by definition, no single entity has control over how the networks are planned, deployed and used. Because of this, the interference situation for very dense deployments is unpredictable, making it difficult to guarantee QoS for delay-sensitive applications such as multiplayer interactive games, VoIP, video telephony, etc. For other applications, Wi-Fi may or may not work fine. Without question, the popularity

of Wi-Fi is skyrocketing, prompting the need for additional spectrum allocation. Efforts are underway in some countries to allocate additional 5 GHz spectrum for unlicensed operations. The 60 GHz band has also been earmarked for specific Wi-Fi applications such as wireless displays and wireless docking operating within a close range (e.g., within a room).

Question 1: IDA invites views on adopting a licence-exempt approach for WSDs in Singapore, subject to the devices meeting the conditions set by IDA.

Qualcomm commends the IDA for the leadership role it is taking in support of the introduction of new technologies and services. As is always the case, there is a need to balance the potential benefits of the introduction of new technologies/services (in this case on an unlicensed basis) against the potential risks that could be caused to existing or planned primary services. Our submission is intended to emphasize the need to release 694 - 806 MHz for licensed mobile broadband services as soon as feasible and to ensure that an efficient and sustainable regulatory regime is put in place to protect the licensed primary mobile service from harmful interference that could be caused to/from license-exempt white space devices (WSDs) operating in adjacent frequency bands. Qualcomm seeks to ensure that the introduction of licensed mobile services in 694 - 806 MHz is not delayed or jeopardized in any way by the early introduction of unlicensed WSDs.

Qualcomm was pleased to see the joint announcement made in June 2013 from the regulators of Singapore, Indonesia, Malaysia and Brunei on their plans to harmonize 698 - 806 MHz spectrum ("the 700 MHz spectrum") in alignment with the APT 700 FDD band plan, thereby re-purposing broadcast spectrum for mobile telecommunications services.[2] The growth in mobile data traffic over the last five years has been staggering and the 700 MHz spectrum is now viewed by most countries around the world as an essential resource to help relieve this explosively increasing demand.

Recent estimates from Cisco[3] show the expected exponential increase of mobile data in the years to come. More precisely "[G]lobal mobile data traffic will increase 13-fold between 2012 and 2017," increasing at a 66 percent compound annual growth rate (CAGR). Additionally, mobile network connection speeds will increase seven-fold by 2017, from 526 kbps in 2012 to 3.9 Mbps.[4] Singapore itself is an example of the high growth that has been seen in mobile data in recent years, rising from 0.68 petabytes by the fourth quarter of 2008 to 5.9 petabytes four years later, a CAGR of 72 percent. Total wireless broadband subscriptions reached a penetration rate of 169 percent in 1Q 2013, with 3G mobile subscriptions representing more than 60 percent of wireless broadband subscriptions.[5] Accordingly, mobile trends in Singapore suggest the need for more spectrum for licensed mobile broadband services in the near future.

From a policy perspective, Qualcomm encourages the government of Singapore to prioritize and accelerate the analog to digital TV transition, restacking the digital TV channels as closely together as possible in the lowermost portion of the UHF band. This would free the upper portion of the UHF band for new mobile broadband services and make the most efficient use of scarce spectrum resources.

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[2] https://www.ida.gov.sg/About-Us/Newsroom/Media-Releases/2013/Brunei-Darussalam-Indonesia-Malaysia-and-Singapore-Pledge-Commitment-To-Align-With-The-Asia-Pacific-Telecommunity

[3] Cisco Visual Networking: Global Mobile Data Traffic Forecast Update, 2012-2017. February 6, 2013. Available at: http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html.

[4] Id, pg. 3.

[5] See IDA: http://www.ida.gov.sg/Infocomm-Landscape/Facts-and-Figures/Telecommunications#9 and http://www.singstat.gov.sg/statistics/latest_data.html#8/.

Moreover it would provide certainty as to where vacant spectrum (so-called TV White Space or TVWS) may exist after the transition to digital broadcasting TV. Before introducing new commercial WSDs as an overlay/underlay in the 694 – 806 MHz frequency range, Qualcomm encourages the government of Singapore to finalize its policies and planning for digital switchover and the future of the 694 – 806 MHz. It is worth noting that in the United States and United Kingdom, two countries to which Singapore has looked for guidance with respect to regulation of WSDs, the digital TV transition was completed long before commercial WSDs were introduced. In fact, to this day, there are very few WSDs operating commercially in either country. Cross-border coordination requirements will, understandably, have an impact on the digital TV transition process and it may not be possible to restack as tightly as would ideally be desired. In any case, given the relatively limited number of analog TV channels in Singapore and the spectrum efficiencies inherent in digital TV technology, there should still be considerable contiguous digital dividend that can be realized.

Qualcomm encourages the IDA to exercise caution and ensure that the new regulatory regime for commercial WSDs does not jeopardize the plans for licensed mobile broadband in the 694 - 806 MHz band. The final policies and regulations developed should give priority to licensed mobile broadband services in the 694 - 806 MHz band which are based upon established technologies with proven track records and robust ecosystems currently providing over 6 billion wireless connections across the globe.

The consultation states that "the overall regulatory framework will be designed to ensure coexistence between WSDs and the existing incumbent users of the TV VHF/UHF band, which are broadcasting services, wireless microphones and Private Mobile Radio ("**PMR**").[6] Qualcomm has concerns that the proposed framework may not have been designed to ensure adjacent-band coexistence between WSD and the *planned* users of the band which include the primary mobile service. Protection to both existing and planned primary services must be ensured. This point is supported by an ITU Discussion Paper on TV White Spaces which states that "[i]f the nature of the primary service changes, let's say from broadcasting to mobile (...), then it will be necessary to assess the interference risk from TVWS devices into the new primary service and their potential reallocation to another band."[7] These interference concerns are relevant both in the bands where WSDs are expected to operate as well as adjacent bands.

In the United States, the Federal Communications Commission (FCC) is currently considering plans to release additional licensed spectrum below 698 MHz via an incentive or reverse auction. While the exact frequency plan has not yet been decided, it is expected that the total amount of TVWS in the United States will be further reduced as a result of this proceeding. The FCC is considering whether any of the 600 MHz spectrum can be set aside for unlicensed, and Qualcomm's submissions on this matter have revealed that the co-existence issues cannot be overcome.[8] Similarly, in the United Kingdom, Ofcom has "considered the potential change in use of the "700 MHz" band (694 – 790 MHz) from DTT use to mobile use, (consequently affecting) the amount of spectrum available for white space devices."[9] Indeed operations in TVWS have been considered opportunistic usage of spectrum that would otherwise lie fallow.[10]

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[6] Consultation page 2, para 4.

[7] GSR 2013 Discussion Paper – TV White Spaces: Managing Spaces or Better Managing Inefficiencies?, July 19, 2013, pg. 14 and pg. 19.

[8] Qualcomm Incorporated, "Reply Comments of Qualcomm, Incorporated In the Matter of Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions," (March 12, 2013), available at http://apps.fcc.gov/ecfs/document/view?id=7022130311.

[9] Ofcom, "TV White Spaces: A consultation on white space device requirements", November 22, 2012, footnote 12, pg. 5.

[10] "White space devices offer a creative and efficient way to use spectrum that would otherwise lie fallow." http://media.ofcom.org.uk/2013/04/26/ofcom-invites-industry-to-pilot-%E2%80%98white-space%E2%80%99-devices/?utm_source=updates&utm_medium=email&utm_campaign=whitespaces.

Question 2: IDA invites views on designating a restricted number of TVWS channels to support the deployment of services that require certainty of spectrum access.

These channels should not be designated above 694 MHz. Please refer to Qualcomm's response to Question 4 below.

Question 3: In the event where IDA designates channels to support such services, IDA invites views on the appropriate regulatory approach in designating and managing these TVWS channels and the regulatory framework for the operations of prioritised WSDs.

These channels should not be designated above 694 MHz. Please refer to Qualcomm's response to Question 4 below.

Question 4: IDA invites views on allowing operation of WSDs in the 694 MHz – 806 MHz band until IDA allocates these frequencies for IMT deployment.

Allowing WSDs to operate in the 694 – 806 MHz band during the interim period before digital TV restacking and analog switch off takes place, creates significant commercial risks for both WSDs and planned mobile broadband services.[11] These risks, outlined below, could exceed any temporary benefits accrued in the interim period. As IDA indicates in paragraph 12 of the Consultation Paper "[t]he 694 MHz to 806 MHz band has been earmarked for International Mobile Telecommunications ("IMT") services in Singapore…," IDA had previously made this announcement in conjunction with regulators from Indonesia, Malaysia and Brunei at the Infocomm Media Business Exchange in June 2013.[12] Furthermore, the IDA has not demonstrated that the demand for WSDs is sufficient to necessitate use of this spectrum above 694 MHz.

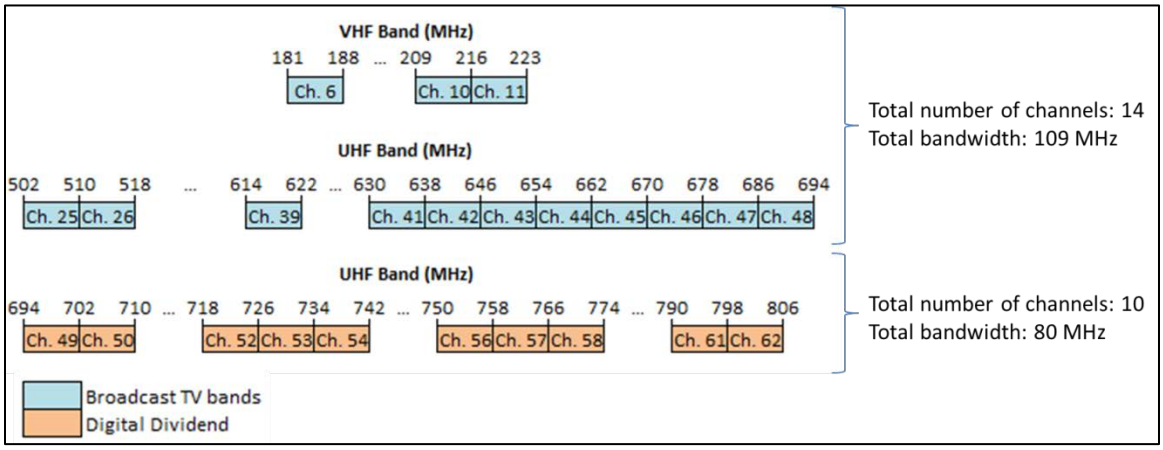
Adopting regulatory safeguards such as those proposed by IDA, *e.g.,* evacuating incompatible WSDs from a band if the primary service changes to a non-broadcasting service, creates interference risks for the new primary service, as well as service disruptions for WSDs moved out of the affected band(s) and practical issues as to how this could actually be accomplished. Specifically, it is possible that there will be great difficulty removing WSDs from the 700 MHz band due to poor device design and/or non-compliance with applicable regulations, causing interference for the new primary service, or possibly even delaying its deployment. In addition, the migration of WSDs out of the affected band(s) risks possible disruption to the WSD services themselves if complications arise with the geolocation database update and/or WSD compliance with the database. Additional difficulties arise if the WSD operational parameters specified in regulation change over time (e.g., out of band and spurious emission limits) and these changes were not foreseen in device design at the time of deployment. To avoid the risk of such scenarios, it is critical to plan the future spectrum usage correctly the first time, providing long-term

[11] "In all these cases, once the use of invasive WSD is authorised in any segment of the UHF band, any subsequent reallocation of that spectrum for telecommunications purposes could be compromised by the continuing use of invasive WSD. If this scenario does eventuate, it seems likely that the value of a spectrum space to prospective licensees would be reduced." *Emerging issues in white space regulation*, Telecommunications Policy 37 (2013) 208-218; Benoit Pierre Freyens and Mark Loney.

[12] https://www.ida.gov.sg/About-Us/Newsroom/Media-Releases/2013/Brunei-Darussalam-Indonesia-Malaysia-and-Singapore-Pledge-Commitment-To-Align-With-The-Asia-Pacific-Telecommunity.

security of spectrum tenure by clearly identifying bands for each service in harmonization with global trends. In this specific case, it is important to guarantee that WSDs will be accommodated in spectrum bands below 694 MHz and that the 700 MHz band be reallocated as soon as possible, in advance of 2020, to licensed mobile services. This long-term planning promotes security of tenure and security of investment not just for WSDs, but for all intended users of the band(s).

IDA has not presented any projections of demand for WSDs that would support the need for 189 MHz of spectrum, a large amount of spectrum, to be made available on this basis. As already noted, in the US and UK, there are virtually no commercial WSDs. If only the spectrum to be used for TV broadcasting after the analog switch-off is considered for WSDs, a total of 109 MHz would be available (taking into account the current TV channel assignments), as illustrated in **Figure 2**. In other words, if the 700 MHz band is prioritized for mobile services and WSDs are only permitted in spectrum below 694 MHz, there would still be more than 100 MHz available for WSDs in Singapore, which itself is far more than would be necessary in any foreseeable timeframe.



Source: adapted from IDA Consultation Document on TV White Spaces

Figure 2 - Candidate WSD channels

In absence of compelling information regarding actual or expected WSD spectrum demand, there is no reason to allow WSDs to utilize the 700 MHz band.

In the United States, one of the countries that has arguably made the most progress with respect to permitting WSD operations, it is notable that such operations are not allowed above 698 MHz. Rather the FCC decided to "(...) not permit operation of TV band devices [or equivalently White Space Devices] (...) on TV channels 52-69, as that spectrum has been reallocated for other services and will no longer be part of the TV bands after the digital television (DTV) transition."[13]

Based on industry momentum, the timing for the introduction of IMT in 700 MHz is likely to be sooner than 2020 leaving little time for WSD usage of this frequency spectrum before the WSDs would need to be transitioned elsewhere. Many other countries in the Asia Pacific and other regions have already indicated plans to introduce new mobile broadband services in the 700 MHz band in the short to medium term using the same frequency arrangement as Singapore, that is, the APT700 FDD band plan which has

[13] FCC, "In the Matter of Unlicensed Operation in the TV Broadcast Bands and Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band. First R&O/Further NPRM" October 12, 2006, pg 2.

been standardized by 3GPP as Band 28 and included in the latest version of ITU-R Recommendation M.1036.[14] For example, Australia is planning to commence commercial operations by December 2014, Japan in early 2015, Taiwan in 2014 and New Zealand in 2014. In Latin America, the countries that have announced plans to award and/or auction the 700 MHz band in 2014 and have adopted Band 28 include Chile, Mexico, Brazil and Colombia. Sub-Sahara Africa recently agreed at a regional level to complete the digital migration process by 2015 in order to introduce new mobile services.[15] Indeed the trend across the globe is to re-purpose 700 MHz spectrum for licensed mobile broadband services which are considered to provide the highest-value use for this spectrum. Equipment vendors are developing product solutions to support Band 28 and the GSMA is tracking some of these announcements.[16] Qualcomm is planning chipset support for Band 28 by Q4 2013. Given the explosive growth in mobile data traffic and the need for additional frequency spectrum to alleviate this demand, the timeframes for mobile broadband access to 700 MHz spectrum are likely to be sooner than originally planned.

As WSDs are expected to operate in bands adjacent to mobile broadband services, it is imperative that IDA ensure that significant attention is paid to protection from interference at the band edges, notably around 694 MHz. A 2011 European Conference of Postal and Telecommunications Administrations (CEPT) report notes that two methodologies for deriving suitable protection for the mobile service in the bands adjacent to WSD usage in 470-790 MHz were proposed, but that further study was required to more fully develop these methodologies.[17] As mentioned above, in the United States the FCC is currently considering options to release 600 MHz spectrum through an incentive auction process. As part of that ongoing proceeding, Qualcomm has studied the impact that unlicensed WSD operations will have on mobile broadband operations in adjacent bands. "Qualcomm has found that not only will unlicensed WSD operations interfere with mobile broadband operations, but such WSD operations also will suffer interference from mobile broadband operations."[18] While the interference scenarios and parameters will not transfer directly to the Singapore scenario, this analysis does provide an important reference point for adjacent band compatibility between licensed mobile broadband and unlicensed WSDs, and indicates that rigorous study is still required.

Qualcomm is particularly concerned that WSD equipment, designed to support frequencies within the 694-806 MHz range, would cause harmful interference to/from licensed mobile broadband services once IMT mobile broadband is introduced. Equipment manufacturers require up front information on the specific range of frequency to build to, bandwidths to be supported, out-of-band and spurious emission requirements, jammer tolerance and linearity requirements, among other technical specifications, which is provided in the standards development process. There are technical limits, e.g., filter limitations, to the range in frequency that can be supported and the corresponding requirements to ensure coexistence with adjacent systems, even using state-of-the-art technology. Thus, equipment manufacturers will need to make early decisions as to which range to support in the products that they build. We encourage IDA to ensure these considerations are accounted for in the final regulatory framework.

Qualcomm has no comments on Questions 5 through 32.

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[14] Asian Pacific Telecommunity Report 14 on "Harmonized Frequency Arrangements for the Band 698-806 MHz." http://www.apt.int/AWF-RECREP.

[15] http://www.itu.int/net/pressoffice/press_releases/2013/32.aspx.

[16] http://www.gsma.com/spectrum/events/drivinglteworkshop.

[17] CEPT ECC Report 159, "Technical and operational requirements for the possible operation of cognitive radio systems in the 'white spaces' of the frequency band 470-790 MHz," (January 2011) at 82.

[18] See FN 8 supra.

In summary, Qualcomm favors the use of 694 – 806 MHz for exclusive licensed mobile broadband services. The interim use of this band by WSDs would pose significant risks to planned licensed mobile broadband IMT as well as WSDs.

Sincerely,

Julie Garcia Welch
Senior Director, Government Affairs
Southeast Asia & Pacific

cc: Mantosh Malhotra, Senior Director of Business Development, Regional Head for Singapore, Malaysia, Philippines