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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 Allocation of Spectrum for International Mobile Telecommunications ("IMT") and IMT-Advanced Services and Options to Enhance Mobile Competition* 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 power 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.

As noted in the Consultation Paper, global mobile data consumption is growing at a rapid pace. According to some analyses, 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 an increase in mobile data traffic growth that Qualcomm refers to as "The 1000x Data Challenge."[1] The mobile industry's latest wireless technologies and trends offer solutions capable of

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

meeting the 1000x challenge - some of which are already developed - and there is a robust roadmap for many more.

However, as wireless networks strain to meet the growing demand for mobile broadband services, radiofrequency spectrum availability and access remain critical. While there are many enhancements allowing for more efficient use of existing spectrum, meeting an increase of the magnitude of 1000x will unquestionably require more spectrum. Specifically, governments and regulators will need to make available traditionally licensed spectrum that gives exclusive rights to the licensee (or licensees) on a nationwide, 24x7 basis. Exclusive use allows planned and orderly deployment, and compatibility with other co-existing and planned services, which results in predictable performance and quality of service.

Given the increasing demand for mobile data and the corresponding need for additional spectrum suitable for mobile broadband services, Qualcomm believes the IDA consultation on matters related to such spectrum is quite timely. Below we present our specific responses to the questions raised in the Consultation Paper.

700 MHz

(a) Whether the 700 MHz band should be allocated as a standalone, or coupled with other bands such as the 900 MHz, 800 MHz or the 1.9/2.1 GHz bands.

Qualcomm appreciates that IDA is taking a holistic approach to its spectrum planning for IMT and IMT-Advanced services. The idea of coupling the release of the 700 MHz band with other bands for IMT services is nuanced and will require the IDA to weigh the benefits and drawbacks. In short, the benefits of a multi-band tender process are that a larger pool of spectrum is released into the market and that operators can seek to obtain the spectrum across all available bands that they believe will suit their business and technology plans. The primary drawback, from the regulator's perspective, is that a multi-band tender may result in lower license fee revenues as operators are unable or unwilling to spend as much on multiple licenses simultaneously as they might if the licenses were made available at different times.

Keeping the idea of a holistic approach to spectrum planning in mind, we believe that the most critical aspects of planning for new mobile service spectrum allocations are: a) certainty regarding the auction timeline and the commercial availability of spectrum, and b) the release of as much suitable spectrum as possible in an efficient, transparent and equitable manner. A stable timeline for the release of IMT spectrum is critical to mobile network operators as they make important medium- and long-term decisions regarding their network planning and investments. For example, Hong Kong's Office of the Communications Authority issues a spectrum release plan annually on a rolling basis, or as required, to keep all stakeholders informed about future spectrum release plans.[2]

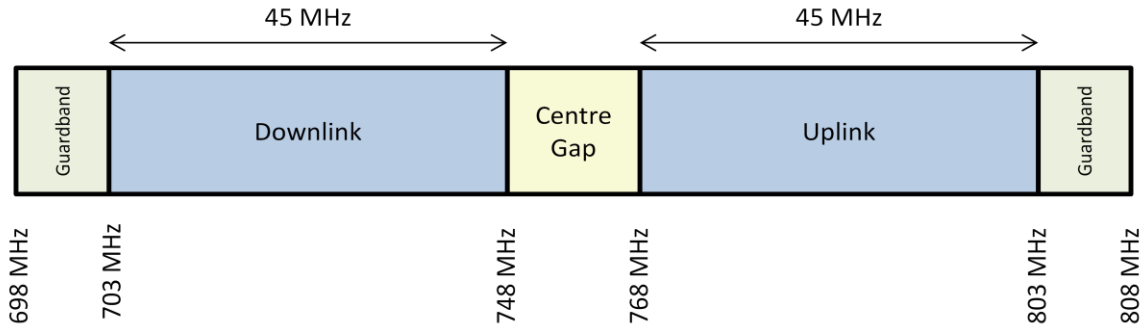
The Asia-Pacific region recently reached an important milestone with the launch of FarEasTone and Taiwan Mobile's networks in Taiwan - the first LTE networks to be deployed using the Asia Pacific

[2] See, for example, "Spectrum Release Plan for 2014-2016," available at http://www.ofca.gov.hk/filemanager/ofca/common/Industry/broadcasting/spectrum_plan2014_en.pdf.

Telecommunity (APT) 700 MHz band plan. It is also important to consider that the APT700 band plan is being adopted around the world. Many Latin American countries, for example, have already committed to the same plan, paving the way for harmonization between countries in both regions. We urge IDA to move as expeditiously as possible to make the 700 MHz band available for use by licensed IMT services.

Importantly, Qualcomm seeks to ensure the full 2x45 MHz of 700 MHz spectrum is released for licensed commercial mobile broadband services, in line with the band plan IDA indicates in Figure 1 below. As detailed further below, utilization of the full 2x45 MHz of 700 MHz combined with the band planning options in the 800 MHz and 900 MHz bands, will ensure the most efficient use of scarce and valuable sub-1 GHz spectrum resources and maximize the amount of spectrum that is available to meet the exponentially increasing demands for mobile broadband.

Figure 1: APT 700 Band Plan



Another important factor that Qualcomm encourages IDA to consider is that the 700 MHz band can be tendered before the analogue television switch-off (ASO). By beginning work now to make the band available for future IMT deployments, IDA can enable a smooth, rapid transition that will enable the spectrum to be put to use delivering high-demand, advanced broadband services as quickly as possible. Countries around the world are planning to award (or have already awarded) digital dividend frequencies ahead of the country's ASO, including Argentina, Australia, Brazil, Chile, Colombia, Italy, Peru, Portugal, Romania, Russia and the United States. The timeframes between award of mobile licenses in the digital dividend bands and full ASO range from just a few months to several years. Australia for example, auctioned the 700 MHz band in April 2013 with full ASO in December 2013 and access to the spectrum allowed from January 2015, while Argentina plans to auction the 700 MHz band in 2014 with full ASO not currently expected until 2020. Notwithstanding the complex issues involved in the analog to digital broadcast television transition, we believe ASO in Singapore may be possible earlier than 2020 and that countries that are working now on their transition process/plan can leverage from the experiences of the many other countries that have already completed this ASO process. It is critical for governments to set clear policy direction, timeframes, and targets for stakeholders to take into account in their medium and long-term planning.

800 MHz

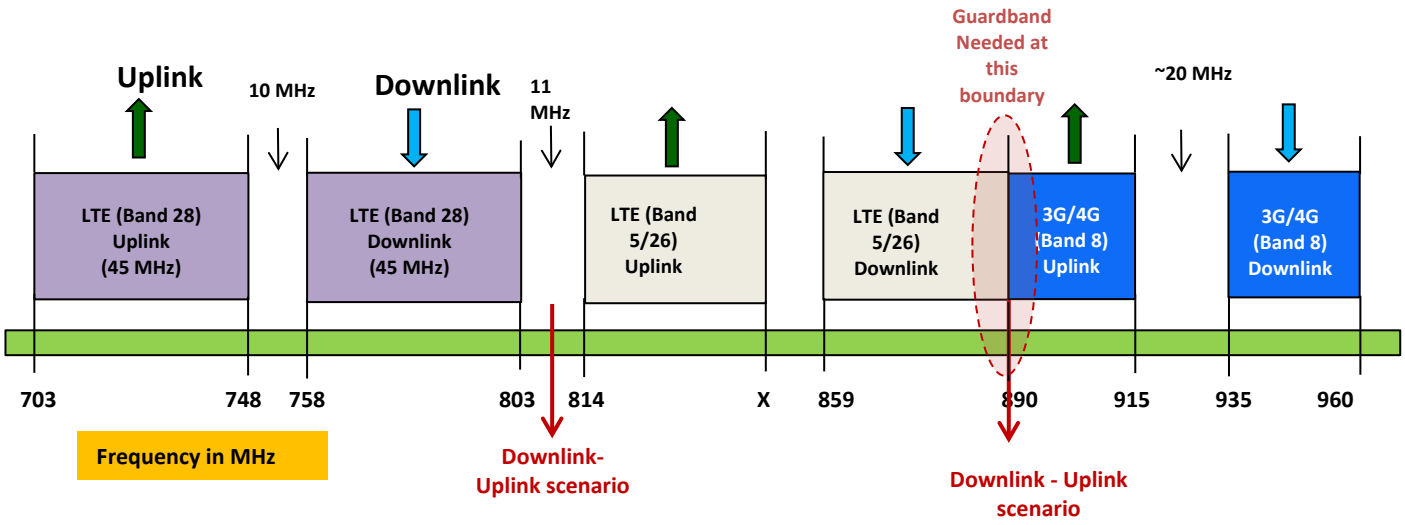
(a) Whether the 800 MHz band should be re-farmed for mobile services;

Yes, Qualcomm strongly believes that the 800 MHz band should be re-farmed for commercial mobile broadband services. Requirements of other existing users (e.g., trunk radio services, SRD) can still be met through various means. By refarming this spectrum for use by IMT services, IDA would unlock the highest-value use of this spectrum and provide the greatest benefits to users across Singapore. Similar initiatives are underway at the national level in other countries in the Asia Pacific and Latin America. Moreover, related discussions have also been taking place at the regional level within the APT Wireless Group.[3]

(b) The band plan that should be preferred by Singapore and the underlying reasons;

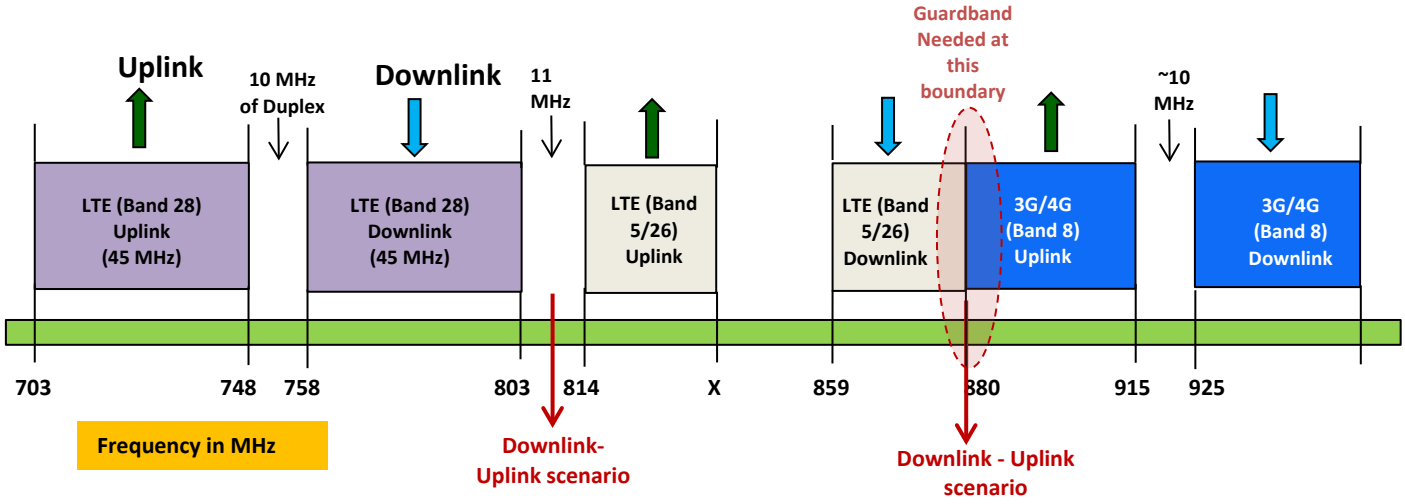
There are two options that can be considered for medium and long-term spectrum planning of the 800 MHz and 900 MHz bands in Singapore: 1) 3GPP Band Class 26 + Band Class 8, or 2) 3GPP Band Class 27 + Band Class 5/26 + Band Class 8. Each of these two options would allow use of either the extended-GSM band (Band Class 8) or the standard GSM band (Band Class 8).

Option 1a: Band 26 + standard Band 8 + Band 28

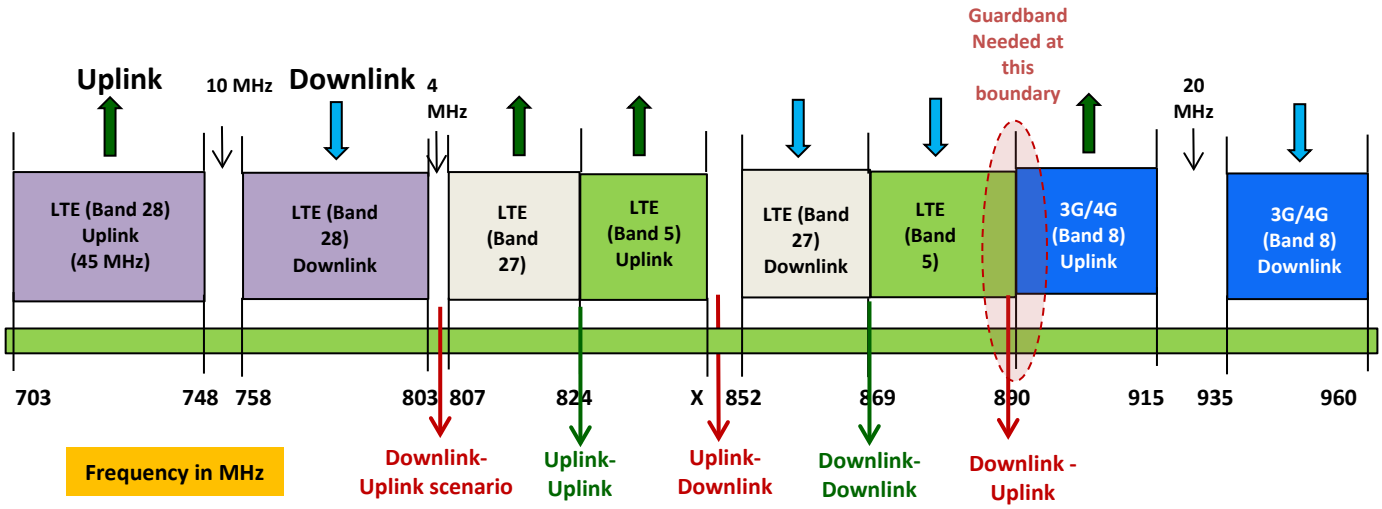


[3] See APT Reports 44 and 27, APT/AWG/REP-44, APT/AWG/REP-27.

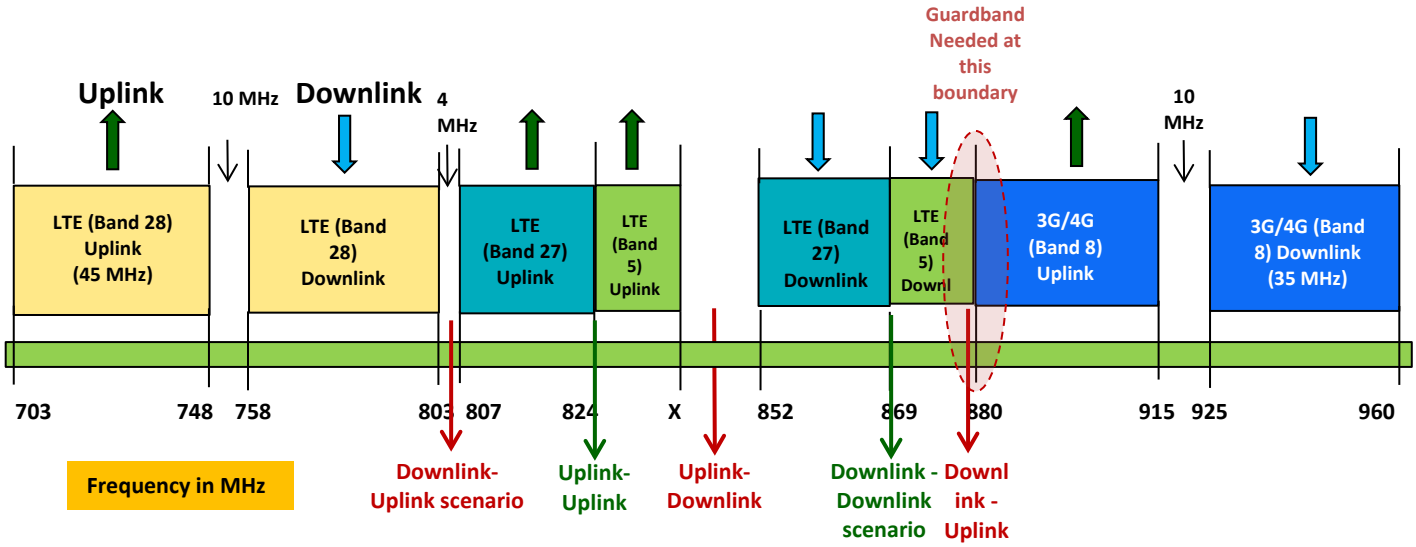
Option 1b: Band 26 + extended Band 8 + Band 28



Option 2a: Band 27 + Band 5 + standard Band 8 + Band 28



Option 2b: Band 27 + Band 5 + extended Band 8 + Band 28



Qualcomm understands the reasons why IDA is inclined towards the Band 26 option. There are already some commercial deployments using equipment based on this relatively new band class in Korea, Japan, the United States, and the prospects for increased ecosystem development seem promising.

Qualcomm believes the Band 27 option is also very attractive. While commercial deployments may still be limited, there are a number of countries, particularly in the Asia Pacific and Latin American regions, that are already planning Band 27 usage. Band 27 options combined with Band 28, Band 5, and Band 8 would constitute the most efficient use of 700 MHz, 800 MHz and 900 MHz spectrum resources. One additional consideration is that 806-824 / 851-869 MHz has already been identified for public protection and disaster relief in the Asia Pacific region (i.e., ITU region 3) in ITU Resolution 646 (Rev WRC-12) thus some countries that have public safety requirements are considering possibilities for LTE-based broadband public safety in some smaller sub-set of this band. Under Agenda Item 1.3, WRC-15 will review Resolution 646.

As noted in the Consultation Paper, the eventual band plan chosen must be selected in coordination with Singapore's immediate neighbors. Harmonized frequency usage among Singapore and neighboring countries will greatly reduce the potential for cross border interference, maximize the amount of spectrum that can be utilized by mobile broadband and increase the economies of scale for user devices.

(c) Details of transitional issues to migrate existing services and systems in the 800 MHz band to the revised band plan;

Regarding SRD's, to avoid frequency overlap with mobile broadband, we recommend migrating those operations in 866-869 MHz to an alternate SRD frequency band, with one possible option being the 920-

925 MHz as indicated by the IDA. As much of the existing equipment should support multiple SRD bands, this migration would be facilitated. APT Report 35 lists the 862-960 MHz frequency range as one of the possible frequency bands for harmonization of SRD.[4] We also note there is ongoing work within the APT Wireless Group towards further regional harmonization of frequency spectrum for SRD's.

(d) Possible impact to end users of digital trunked radio and SRD, if, as a result of the eventual 800 MHz band plan: (i) the end users do not have to be migrated but will have to coexist with mobile broadband services; or (ii) the end users have to be migrated; and

No comment.

(e) Possible co-existence issues between mobile broadband, and digital trunked radio and SRD/RFID.

Qualcomm proposes that IDA develop a clear roadmap for the band and avoid frequency overlap between mobile broadband and other services which would result in interference for all services involved. This, in turn, can lead to degraded quality of service for end users and inefficient use of the spectrum resource. We therefore believe that the appropriate path forward is for IDA to develop a proposed transition plan for clearing the band, including appropriate timelines and milestones, and to consult with industry on that plan. By consulting with industry on the transition plan, IDA will not only ensure that it has timely input from operators, but also increase the likelihood of stakeholder support for the plan that ultimately emerges from the consultation process.

900 MHz

(a) Whether the band should be re-allocated as a standalone band in a market-based allocation framework, and if so, the preferred timeframe for such an allocation exercise;

(b) Whether the band should be coupled with other spectrum bands for allocation, and if so, which bands and the preferred timeframe for such an allocation exercise; and

(c) The underlying reasons for your views on the above.

As noted above in response to questions related to the 700 MHz band, Qualcomm believes that the priorities with respect to spectrum planning should be to ensure a high level of certainty regarding when spectrum will be made available (and in what bands and quantities), and that the release of suitable spectrum takes place in an efficient, transparent and equitable manner. These factors are crucial to mobile network operators considering decisions related to their network planning and investments.

We do note that several jurisdictions have conducted multi-band auctions, although determining whether they have been considered "successful" may depend on whether they are viewed from the perspective of the regulator, successful bidders or unsuccessful bidders. As noted in our comments on the 700 MHz band, there are both potential benefits and drawbacks to a multi-band tender process.

[4] Asia Pacific Telecommunity Report 35 on "The Frequency Bands for Harmonized Use of Short-Range Devices (SRDs)," March 2013.

IDA will need to consider the appropriateness of offering multiple bands at once, including the issue of substitutability.

With respect to the timing of a 900 MHz assignment process, Qualcomm believes that the most prudent approach is to make the spectrum available as early as is feasible, offered with long-term rights, in conjunction with a clear timeline for the expected assignment and availability of other IMT-suitable bands. We believe that offering short-term spectrum rights, even when intended to coordinate the assignment process, introduces uncertainty and distortion into the market for mobile network operators. Instead, the coupling of long-term spectrum rights with a clear indication of when other, complementary spectrum will become available, allows operators and investors the appropriate certainty to make long-term plans that require significant investment not only in spectrum rights, but in infrastructure.

Sub-1 GHz bands

(a) The technical issues relating to the allocation of the Sub-1 GHz bands for mobile broadband services, in particular, the guard band requirements between the adjacent bands (e.g., 700, 800 and 900 MHz bands) for mobile broadband services.

Guard band will be needed at the boundary between the Band 5/26 downlink and the Band 8 uplink, regardless of whether this boundary is at approximately 880 MHz, allowing extended-GSM operations, or at approximately 890 MHz. The recommended size of the guard band will be based upon a number of factors including the mobile broadband technology (e.g., LTE, HSPA, GSM), carrier bandwidth, additional filtering and the extent of co-location between operators. Guard band, additional filters and effective antenna placement can be used to solve the effect of Band 5/26 *base station* transmit interference into Band 8 *base station* receive. Although additional filters are not possible in mobile devices, the probability of Band 8 *mobile* transmit interference into Band 5/26 *mobile* receive is extremely low and, therefore, the impact is considered acceptable. As such, Band 5 and Band 8 successfully coexist today in a number of countries.

There is at least 4 MHz of guard band between the upper edge of the Band 28 downlink at 803 MHz and the lower edge of the Band 27 uplink at 807 MHz. Coexistence between these two bands was considered during the 3GPP standardization process and there are no issues.

As both Band 27 and Band 5/26 operate in conventional duplex mode (uplink in the lower band pairing), there are no uplink/downlink boundary interfaces and, therefore, no guard band requirements.

1.4 GHz

(a) Indication of any industry interest in the use of the 1.4 GHz band.

Qualcomm believes that the 1.4/1.5 GHz band, also known as the L-band, will be an important resource to meet future mobile broadband demand. As mobile broadband demand continues to grow, administrations are seeking additional spectrum bands that can be used to increase capacity and enhance the user experience. Qualcomm believes the L-band is an ideal candidate for such

consideration in Singapore and beyond, and notes the support this band is receiving under ITU-R 2015 World Radio Conference (WRC-15) Agenda Item 1.1 on additional spectrum for IMT.

Ongoing work at the ITU, specifically in ITU-R Joint Task Group 4-5-6-7 (JTG), has included consideration of portions of the L-band for mobile use and Qualcomm expects that there will be corresponding proposals to WRC-15. There were a number of inputs from administrations to the APT WRC-15 Preparatory Group meeting (APG) that was held last week proposing to allocate and identify portions of the L-band for IMT:

- Australia (1427-1518 MHz)
- Indonesia (1427-1518 MHz)
- Korea (1452-1492 MHz)
- New Zealand (1350-1525 MHz)
- Vietnam (1350-1400 MHz, 1452-1492 MHz)

While it may be early to predict final outcomes on this band at the WRC-15, it is clear there is considerable support for allocating and identifying some portion of the L-band for mobile use.

We note that there have already been developments 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 CEPT ECC decision was approved on the "harmonized 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 to SDL.[5] This decision was approved with significant support, with 25 administrations indicating that they will implement the ECC Decision.

Brazil submitted a document to the Inter-American Telecommunication Commission (CITEL) in 2013 encouraging inputs from other countries toward a harmonized use of the band in the region, as it was considering frequencies between 1350 MHz and 1525 MHz as candidate bands for IMT identification at WRC-15.[6] This year, the Brazilian delegation noted that countries including Brazil, Colombia and Mexico were considering use of the L-Band and, in response to WRC-15 agenda item 1.1, suggested that CITEL propose that 1350-1400 MHz be allocated to the mobile service on a primary basis and that the 1350-1400 MHz and 1427-1518 MHz bands be identified for use by IMT at WRC-15.[7]

3G bands

(a) To allow the deployment of 4G and IMT-Advanced systems and services in the 3G bands.

Qualcomm agrees with IDA's intent to allow deployment of 4G and IMT-Advanced services in the existing 3G bands, as long as such deployments do not negatively affect existing 3G operations. As

[5] See Minutes of the 35th ECC Meeting, FM 48(13)061 Doc. ECC (13)090 Rev. 2 available here.
[6] CCP.II-RADIO/doc. 3378/13, "Supporting the future use of the L-Band (1350 MHz – 1525 MHz) for IMT in relation to WRC-15 Agenda Item 1.1," (October 25, 2013).
[7] CCP.II-RADIO/doc. 3525/14, "Preliminary proposal on Agenda Item 1.1, 1350 MHz – 1518 MHz (the L-band)," (March 7, 2014).

noted in the Consultation Paper, 3G technologies are expected to remain in use for many years, both for domestic users and inbound roamers. Qualcomm supports flexible spectrum use and technology neutrality, but also recognizes the importance of maintaining high-quality service for those users taking advantage of 3G networks currently and in the foreseeable future.

However, as IDA also notes, the current 3G spectrum rights do not expire for another seven years, and operators may be interested in redeploying some of their current 3G spectrum for 4G services before that time. Qualcomm believes that the approach outlined in the Consultation Paper would provide operators with the flexibility to redeploy their existing spectrum on their own schedule, and that there is no need to mandate any specific technology or service.

TDD bands

(a) Indications of industry interest in the allocation of long term rights in the TDD bands, as well as planned services (including small cells) and target market segments for the use of these bands;

(b) Views on whether the use of the TDD bands solely for the deployment of in-building TDD systems is feasible, and the underlying considerations thereof;

(c) Views on whether the use of TDD bands for partial deployment of outdoor and in-building TDD systems is feasible, and the underlying considerations thereof;

(d) views on the use of TDD bands for small cell deployment as part of a HetNet;

(e) Views on the mitigation techniques requirement for co-existence (e.g., separation distance, transmit power, and UL-DL configuration);

(f) views on the implication of the TDD bands on a half-band sharing basis with neighbouring jurisdictions; and

(g) views on the implication of the TDD bands on a full-band sharing basis (primarily for in-building deployment) with neighbouring jurisdictions.

Interest in LTE TDD has strengthened. GSA confirms that more than 10 percent of commercial LTE networks incorporate the TDD mode. Worldwide, 28 LTE TDD systems are commercially launched in 21 countries, including 13 operators who have deployed both FDD and TDD modes.[8] The frequency bands where TDD deployments may be the most advanced include 2.3 GHz and 2.5 GHz (center gap). Commercial deployments in China, India, Hong Kong and Australia are fueling the industry development in 2.3 GHz. Notably, in Australia, Optus' 2.3 GHz LTE TDD network is setting records in terms of downlink speed by aggregating multiple 20 MHz LTE carriers.

Qualcomm welcomes the IDA's initiatives to make the 2.3 GHz and 2.5 GHz (center gap) TDD bands available on a short term basis through existing frameworks and encourages the IDA to also make these bands available for long term allocation.

[8] Evolution to LTE Report, GSA, January 2014.

With regard to the proposals for sharing the 2.3 GHz and 2.5 GHz TDD spectrum between neighboring jurisdictions, Qualcomm encourages the IDA to continue the dialogue with neighboring countries and explore technical and operational techniques that would allow full-band sharing without onerous regulatory constraints, e.g., limited to indoor.

3.5 GHz

(a) Indications of industry interest in the allocation of long term rights in the 3.5 GHz band, as well as planned services and target market segments for the use of these bands;

Qualcomm has invested considerable resources/R&D in technology solutions and innovations to address the mobile data spectrum challenge, including our work on small cells. 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 and viral 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.

Small cells are ideal for higher spectrum bands, such as 3.5 GHz, and there is increasing industry interest and development in small cell technology solutions for this frequency band. We understand portions of the C-band are currently used by the fixed satellite service (FSS) in a number of countries. However, the usage of C-band by FSS varies by country/region, and small cell technology presents new opportunities for sharing/coexistence with the FSS. We will endeavor to keep the IDA informed on small cell technology developments, particularly as they may relate to the 3.5 GHz band. We also encourage the IDA to explore possibilities for releasing a portion of the 3.5 GHz band for mobile small cell use.

Ongoing work at the ITU, specifically in ITU-R JTG 4-5-6-7, has included consideration of the 3.5 GHz band for IMT use, and Qualcomm expects that there will be efforts to identify the band (or portions of the band) for IMT at WRC-15. It is important to note that the 3.4-3.5 GHz and 3.5-3.6 GHz portions of the band have already been identified by country footnote for IMT in a number of countries across the globe, including the Asia Pacific. In addition, in Europe, harmonization of the 3.4-3.8 GHz band for mobile usage is already well underway.[9] Given it can take up to 10 years for new internationally harmonized spectrum for mobile to be licensed and used to deliver services, in order to meet the expected mobile data demands in 2020 and beyond,it will be imperative that WRC-15 take decisions on additional mobile allocations and identifications in the C-band.

(b) Views on whether the use of the 3.5 GHz bands solely for the deployment of in-building mobile systems is feasible, and the underlying considerations thereof;

[9] The process was initiated in 2008 through 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

Qualcomm believes that limiting use of 3.5 GHz bands to the deployment of in-building mobile systems would be challenging and, perhaps more importantly, would place a significant burden on IDA to enforce such a regulation. Instead, careful planning to ensure adequate interference protection both to and from mobile services operating in the band would be a more prudent approach.

(c) Views on possible impact to end users of FSS and TVRO, if (i) the end users do not have to be migrated; or (ii) the end users have to be migrated; and

No comment.

(d) Views on possible co-existence issues between TDD systems, and FSS and/or TVRO systems.

No comment.

Other policy considerations for development of HetNet:

(a) Views on key policy areas related to technical, service provisioning or end-user impact that should be considered in the deployment of HetNet; and

(b) Other policy implications that may arise with HetNet.

Qualcomm agrees that meeting the increasing demand for mobile broadband will require new solutions, including HetNets. As multiple technologies and an increasing number of spectrum bands are employed to deliver seamless and pervasive wireless service coverage, deployment of Singapore's HetNet will need to take into account the potential for interference especially with the proliferation of small cells. In fact, small cells will only work in practice if there is interference mitigation and coordination built into the HetNet, as well as interference mitigation or cancellation built into individual user devices. In seeking to coordinate multiple technologies, HetNet should also include mechanisms to ensure quality of service (QoS) for end users. Vendors are actively developing new and improved means by which to manage QoS, including directing traffic to the most appropriate access network. It will be important that as Singapore's HetNet is developed and implemented that QoS obligations be factored into the process.

We do not believe, however, that IDA should take an active role in selecting (or limiting) any particular vendor solutions. As networks continue to evolve and, as in the case of the proposed HetNet, be bound together to provide seamless connectivity, technology neutrality and flexible spectrum use become increasingly important. Removing – or not imposing – unnecessary technical restrictions on the use of spectrum to provide mobile services will enable more rapid evolution and enhancement of the HetNet as technologies advance and new means of directing users to the most appropriate access network are developed.

Conclusion

Qualcomm appreciates the opportunity to provide input to the IDA on this Consultation Paper. Should you desire more detail on Qualcomm's views relating to these topics, please do not hesitate to let me know.

Sincerely,

Julie Garcia Welch

Senior Director, Government Affairs, Southeast Asia & Pacific