WiMAX Forum™ Recommendation for Infocomm Development Authority of Singapore (IDA) for 2.3 and 2.5 GHz Broadband Wireless Spectrum

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Table of Contents

Figures

Tables

1. Introduction

The purpose of this document is to provide a recommendation to Infocomm Development Authority of Singapore ("IDA") for spectrum requirements for Point-to-Multi Point (PMP) Terrestrial Broadband Wireless Systems operating in the newly allocated 2.3 and 2.5 GHz bands.

The WiMAX Forum is pleased to submit this comment in response to Infocomm Development Authority of Singapore's Consultation Paper on DEPLOYMENT OF WIRELESS BROADBAND TECHNOLOGIES IN SINGAPORE [1].

The WiMAX Forum, is an industry-led, non-profit corporation formed to help promote and certify the compatibility and interoperability of broadband wireless products using the IEEE 802.16* WirelessMAN* and ETSI HiperMAN* specifications. The Forum's goal is to accelerate the introduction of these devices into the marketplace. WiMAX Certified™ products will be fully interoperable and support broadband Fixed, Portable and Mobile applications.

We applaud IDA's intention to "to proliferate broadband services and usage in Singapore." IDA's inquiry coincides with global spectrum allocation activity in this band from bodies including the ITU-R [2], the European Commission [3], and the United States [4]. The WiMAX Forum believes this represents a great opportunity for global harmonization and coordination of this important band, which can result in significant benefits to consumers on a world wide basis.

Specifically in response to IDA's questions, we believe:

1. Deployment of WiMAX Certified* solutions in these spectrum bands for wireless broadband access will not only provide coverage for broadband access gaps for businesses and homes, but will also introduce entirely new usage models that will, over time, yield a network that allows consumers to connect at high speed to the Internet "wherever and whenever" in metropolitan areas.
2. The coexistence issues related to the deployment of broadband wireless systems have been extensively studied in the IEEE 802.16* standardization group and regional spectrum management organizations like the CEPT. IEEE 802.16 has published a "Recommended Practice"[1] document that details a number of recommendations aimed at addressing the inter-

[1] IEEE802.16.2: "IEEE Recommended Practice for Local and Metropolitan Area Networks; Coexistence of Fixed Broadband Wireless Access Systems"

operator coexistence issues between fixed systems operating co-channel in adjacent areas and in adjacent channels in the same area. The FDD and TDD usage in these bands has been extensively studied and addressed in ITU-R reports, and the WiMAX Forum intends to make available specific coexistence studies between IMT-2000 interfaces and IEEE 802.16.

3. As mentioned above, global activity is under way to harmonize and allocate the 2.5GHz band. The WiMAX Forum would encourage IDA's active involvement in this process.
4. The WiMAX Forum strongly supports permitting existing 3G operators to deploy wireless broadband technologies in their spectrum, in addition to their 3G systems. IDA is correct in believing that, "These measures will help facilitate the deployment of wireless broadband technologies, thereby offering consumers a wider variety of broadband options."
5. The WiMAX Forum believes IDA should exercise caution in establishing spectrum caps in this nascent service.
6. WiMAX Forum believes QoS standards, other than those needed for safety and national security, should be set by the market. In a competitive environment, consumers should be allowed to choose between cost and levels of service.

This recommendation is designed to support deployment of spectrally efficient, IP based fixed, portable and mobile broadband wireless network systems for Internet access and voice applications. In particular, the recommendation supports harmonized radio frequency channel arrangements for these usage models. In this document, the Forum provides examples of a Broadband Wireless Access (BWA) deployment using equipment that adheres to the IEEE 802.16* WirelessMAN* standard [5].

The rest of the document is organized as follows: Section 2 responds to IDA's specific Consultation; Section 3 provides additional technical information; and Section 4 lists references.

2. Response to IDA Consultation [1]

a) IDA invites views and comments on the potential of and benefits arising from the deployment of wireless broadband technologies.

WiMAX Certified* equipment is designed and configurable for a range of broadband wireless access deployment scenarios. These scenarios include the possibility for longer ranges (up to 50km) in clear (LOS) outdoor conditions to shorter range non-LOS deployments in cluttered urban environments. Over this range of conditions the common feature is the capability to reliably deliver broadband connectivity to the business & home users.

There is considerable demand for flexible, quickly deployable wireless broadband access. For this reason, 802.16 was designed from the ground up to support multiple service levels – for example, guaranteed T1 or E1-level services for business, and best effort DSL-speed service for home consumers. Quality of Service also designed into the standard to allow for services that require low latency, such as voice and video.

With the flexibility that wireless broadband access affords, a service provider can offer premium "on demand" high-speed connectivity for events such as trade shows, with hundreds or even thousands of 802.11 hot spot users. These Wi-Fi hot spots would use 802.16 solutions as their backhaul to the core network. Such "on demand" connectivity could also benefit businesses, such as construction sites, that have nomadic broadband connectivity needs.

Lastly, the impact of this technology can be very significant in developing nations where service providers haven't deployed wired infrastructure or where there isn't sufficient quality wiring to support a growing computer-literate population. Especially for greenfield deployments, wireless broadband access is far easier, faster and cheaper to deploy than new wired infrastructure.

b1) IDA inquires about the coexistence issues that need to be considered with regards to the deployment of FDD & TDD in the same geographical area.

The WiMAX Forum expects to certify both FDD (FDD/HFDD) and TDD systems in the 3.4-3.6 GHz fixed wireless bands. For 2.3 and 2.5 GHz which is not as established as the 3.5 GHz band, it is still early to predict what manufacturers will develop although we do see a trend towards 5 MHz channelizations and TDD. The system manufacturer members of the WiMAX Forum ship well over 90% of all "pre-standard" wireless broadband access equipment. As such, there are examples of "pre-standard" FDD & TDD wireless broadband access systems operating in the same geographical area. Some of these cases have required additional guard band be introduced.

The coexistence issues of FDD and TDD in this band have been extensively studied in the ITU-R and are documented in Report ITU-R M.2030 [7]. Recently the ITU-R Working Party 8F completed a Draft New Report ITU-R M.[IMT.MITIGATION] [8] that addresses the issues identified in Report ITU-R M.2030. IMT.MITIGATION considers techniques to improve compatibility between IMT-2000 time division duplex (TDD) and frequency division duplex (FDD) radio interface technologies operating in neighbouring frequency bands and in the same geographic area. Report ITU-R M.2030 analysed and presented results of the consequences of adjacent channel interference on FDD and TDD compatibility within the 2500-2690 MHz band for a range of scenarios. This report considers techniques, within specified classifications, to mitigate this interference, and hence to improve coexistence between TDD and FDD mobile networks in neighbouring frequency bands and in the same geographic area.

The scenarios considered were BS-BS, WCDMA-TDD, Macro-to-macro line of sight (LoS), Macro-micro (vehicular), Micro-micro (LoS), Micro-micro (pedestrian), MS-MS. The techniques discussed include Site placement, Antenna separation, Antenna polarization, Adaptive antennas, Transmitter/receiver improvements, TDD power control, Mobile handover, Antenna down tilt, and FDD power control.

The document necessarily focuses on current IMT-2000 air interfaces: “However, the mitigation techniques described in this Report may be also more generally applicable to other frequency bands and to other TDD and FDD radio interfaces.”

The WiMAX Forum intends to make available specific coexistence studies between IMT-2000 interfaces and IEEE 802.16.

b2) The IDA inquires as to whether the 5 MHz, 5.5 MHz or 6 MHz channeling plan for the 2.3 GHz band and the 2.5 GHz band meet industry requirements.

WiMAX Forum sees a worldwide trend toward channelization raster based on multiples of 5 MHz in licensed bands. As the Forum is headquartered in the U.S., we have had the opportunity to ask the U.S. 2.5 GHz spectrum holders if they also see this trend and if they desire a globally harmonized approach. We believe those licensees are supportive of alignment with global trends for 2.5 GHz allocations, namely, IMT-2000 – and that they will use any excess spectrum for additional guard band.

b3) The IDA asks for the appropriate duplex separation (Transmit/Receive) for the FDD wireless broadband technologies in the 2.3 GHz and 2.5GHz bands respectively? What is the minimum, as well as optimal amount of spectrum?

As mentioned above global activity is under way to harmonize and allocate the 2.5-2.69 GHz band. A popular view is paired FDD spectrum on either end of the band, with TDD or a flexible band in the middle.

For the 2.3 GHz band where half as much spectrum is available, the WiMAX Forum believes the spectrum should not be overly burdened by the allocation of paired bands. Given the technology trend towards TDD systems, we believe sufficient spectrum should be made available to deploy cost effective, spectrally efficient TDD solutions.

Historically TDD systems had latency issues that resulted in them being implemented for shorter distance applications (WLAN, cordless phones.) These issues have been solved with modern radio technology. TDD systems are considered by TDD advocates to be more efficient because of their superior ability to support asymmetric uplink and downlink traffic. In addition, the fact that the Tx and Rx utilize the same channel in TDD systems yields significant cost benefits when using Advanced Antennas Systems (AAS). Specifically, one can place multiple antennas in the base station – and thereby benefit from AAS – without needing to place extra antennas on the subscriber station. We believe that the added link budget provided by AAS is critical to successful BWA deployments because historical deployments have shown coverage to be one of the most critical elements for successful deployments.

The WiMAX Forum believes the minimum required spectrum allocation to facilitate a robust broadband wireless market should be 15 MHz for systems using 5 MHz channelization and 30 MHz for systems using 10 MHz channelization. A combination of 15 MHz and 30 MHz spectrum allocations could also be considered. Any remaining spectrum from the total available bandwidth could be considered for deployment of single frequency systems based on 5 or 10 MHz bandwidths.

c) & d) No comment.

e) The IDA welcomes views and comments on the deployment of wireless broadband technologies in the 3G spectrum bands. Are there any technical considerations that the IDA should consider? Please provide detailed supporting reasons for each comment and proposal made.

WiMAX Forum strongly supports IDA's belief that:

> "permitting the 3G operators to deploy wireless broadband technologies that do not belong to the IMT-2000 family of standards in their 3G spectrum……. will give the 3G operators additional flexibility in using their 3G spectrum, and allow the deployment of wireless broadband technologies that operate in the 1.9 GHz and 2.1 GHz bands."

WiMAX Forum believes maximum benefits occur when carriers are free to pick whichever technology fits the allocation and technical parameters. Such technical parameters should be as flexible as possible, such as setting objective interference limits for each license's co-channel (geographical) and adjacent channel (frequency) boundaries. E.g., a licensee should not be limited to putting up a 200-foot antenna at particular coordinates emitting particular power. Instead, it should have operational flexibility (including moving from broadcast to mobile and portable uses) as long as it operates within specified power limits at its boundaries with its co-channel and adjacent channel neighbors.

We note that operators have strong incentive to introduce technologies in a most careful way as to eliminate any interruption to their service.

Moreover as mentioned earlier, WiMAX Forum will make available specific IEEE 802.16 coexistence studies with the IMT-2000 family of air interfaces to assist operators in a smooth introduction of the technology.

f) IDA welcomes views and comments on the eligibility of existing 3G and broadband infrastructure providers for the 2.3 GHz and 2.5 GHz spectrum, and the limit on the spectrum amount for which they could bid.

WiMAX Forum believes IDA should exercise caution in establishing spectrum caps. In a nascent market such as wireless broadband it is difficult to gauge what a minimum amount of spectrum technically necessary is.

In addition such caps can preclude operators from accruing enough spectrum to properly service there customers, and limit economies of scale that can result from aggregation.

g) IDA welcomes views and comments on whether there are issues that may pose problems to achieving transparent and seamless interconnection and open access. IDA further seeks comments on the type and level of QoS standards that will be appropriate and whether the existing set of QoS standards for broadband service providers are applicable for service delivery using wireless broadband networks. Please provide supporting reasons for each comment and proposal made.

WiMAX Forum believes QoS standards, other than those needed for safety and national security, should be set by the market. In a competitive environment consumers should be allowed to choose between cost and levels of service.

h) no comment

3. Technical Appendix:

3.1. Channel Spacing and Center Frequencies

Two sets of harmonized channel spacing are recommended for fixed, portable and mobile deployments. The proposed channelizations support low cost and low complexity RF designs for globally harmonized deployments with minimal to no re-banding required for overlay deployment of fixed, portable and mobile wireless networks.

The following sets of channel spacing are based on a 5 MHz channelization for fixed broadband wireless systems and 5 and 10 MHz channelizations for mobile deployments. In particular, this recommendation is intended to provide operators with the most deployment flexibility with regards to the operational radio frequency bandwidth. The recommended channel spacing options are harmonized with the general worldwide trend toward multiples of 5 MHz based channelization raster both in licensed and licensed exempt bands. Examples of support for 5x MHz channelization include the UK (3.5 GHz band), Korea (2.3GHz band), US (MMDS 2.5 GHz band), IMT-2000 for 2.5 GHz, IEEE 802.16* WirelessMAN* OFDM and OFDMA and licensed exempt allocation.

The WiMAX Forum sees advantages to Time Division Duplexing (TDD) for several reasons including excellent support for Advanced Antenna Systems (AAS) systems -- a crucial option for realization of high spectrally efficient systems with low reuse factor -- lower cost and simplicity of design. Table 1 provides recommended channel spacing and corresponding center frequencies for implementation of TDD systems in 2.3 and 2.5 GHz bands.

Table 1. Channel Spacing and Center Frequencies

Application	Channel Sets Center Frequencies
Fixed	5 MHz Bandwidth: $2202.5 + Nx5MHz, \forall N \in \{0,...,39\}$ $2486 + Nx5MHz, \forall N \in \{0,...,40\}$
Portable or Mobile	5 MHz Bandwidth: $2202.5 + Nx5MHz, \forall N \in \{0,...,39\}$ $2486 + Nx5MHz, \forall N \in \{0,...,40\}$ 10 MHz Bandwidth: $2205 + Nx10MHz, \forall N \in \{0,...,19\}$ $2488.5 + Nx10MHz, \forall N \in \{0,...,20\}$

Note that the channel spacing options recommended above support the easily implementable 2.5 and 5.0 MHz frequency step sizes for 2200-2400 MHz band and 1.0 and 0.5 MHz frequency step sizes for 2483.5-2690 MHz band.

3.2. Spectral Mask

The recommended spectral mask is based on a modified ETSI mask [6] normalized for the channel bandwidths of Section 2. Please note that a single mask is recommended for all possible modulation orders and corresponding spectral efficiencies to address the single but more stringent requirement needed for commonly used adaptive modulation in various candidate technologies. Table 2 specifies the proposed spectral mask for 5 and 10 MHz channel bandwidths.

Table 2. Spectral Mask Break Points

Channel Spacing (MHz)	Point A (MHz) 0 dB	Point B (MHz) -8 dB	Point C (MHz) -32 dB	Point D (MHz) -50 dB	Point E (MHz) -50 dB
5	2.5	2.5	3.57	10	12.5
10	5.0	5.0	7.14	20	30

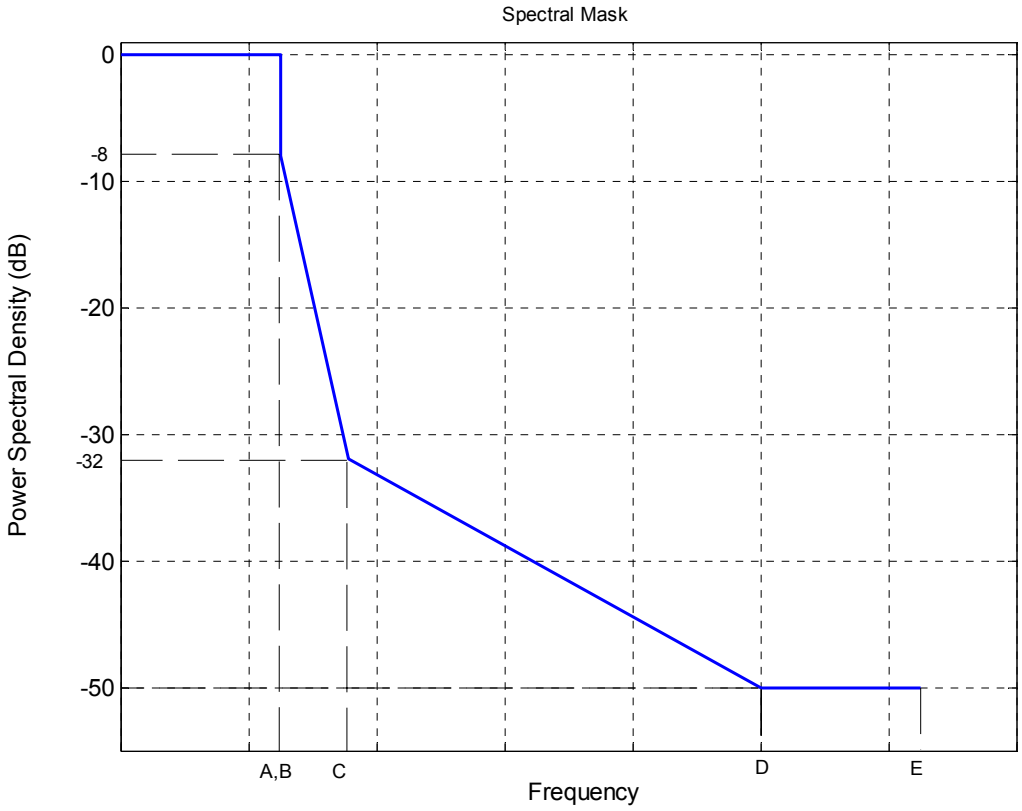

Figure 1. Spectral Mask

Figure 1 shows the proposed spectral mask as specified by break points of Table 2. To illustrate spectral compliance with the proposed mask, we provide an example of a BWA system using

equipment that adheres to the IEEE 802.16* global standard. Figure 2 and Figure 3 show the power spectral densities of the IEEE 802.16* WirelessMAN* OFDM and Scalable OFDMA transmit signals overlaid on the proposed mask for 5 and 10 MHz bandwidths respectively.

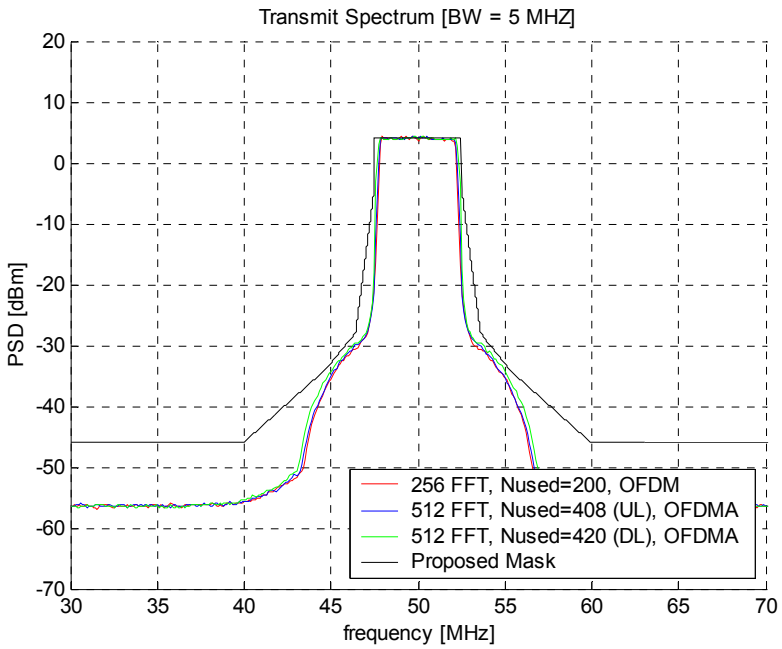

Figure 2. IEEE 802.16* WirelessMAN* OFDM and OFDMA against Proposed Mask (5 MHz BW)

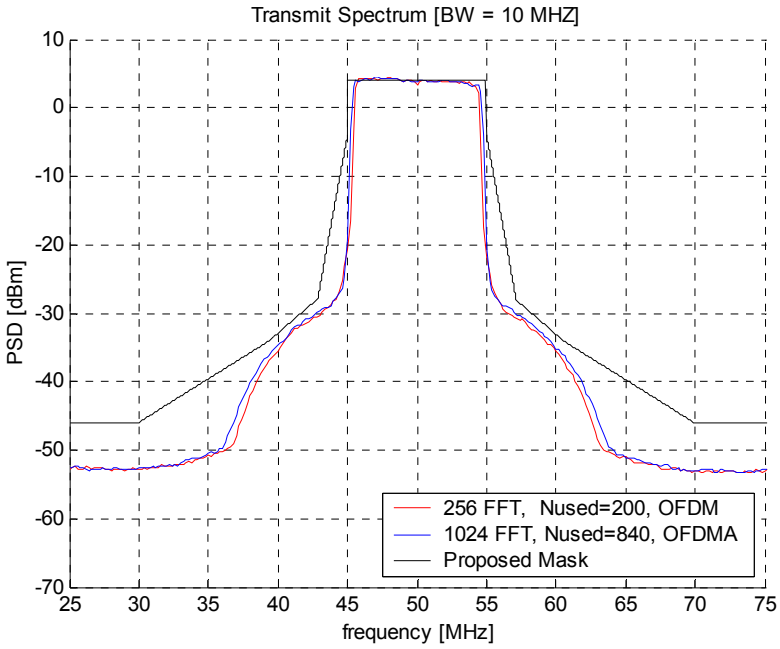

Figure 3. IEEE 802.16* WirelessMAN* OFDM and OFDMA against Proposed Mask (10 MHz BW)

3.3. Maximum Power Level Considerations

Maximum power level and/or EIRP requirements usually depend on many regulatory factors. A 35 dBm maximum transmit power requirement, as specified by ETSI, translates into 53 dBm EIRP at the Base Station (BS) side when a typical 18 dB gain antenna is used. On the Subscriber Station end, maximum EIRP values of 59, 44 and 38 dBm can be achieved when 24, 9 and 3 dB gain antennas are used for fixed outdoor, portable indoor and mobile equipment respectively. From a wireless cellular coverage point of view, these EIRP values support wireless network requirements of the majority of service providers.

3.4. Spectrum Allocation Considerations

Advanced broadband wireless technologies such as IEEE 802.16* WirelessMAN* OFDM and OFDMA support special optional features such as AAS, controlled randomized subchannelization, synchronized frame length and frame start. These features enable the system to support interference mitigation/avoidance and partial loading required for a high spectrally efficient (e.g., Reuse Factor =1, see Figure 4) network design and also efficient, low cost single frequency hot spots.

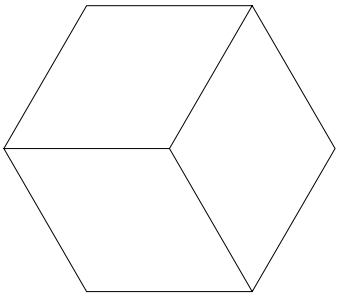

Figure 4. Reuse Factor 1

In order to enable the service providers to deploy low cost, less complex systems -- especially attractive at the early stages of system operation where the network is not fully loaded and low reuse factor is not the first criteria -- a more conservative reuse factor of 3 (see Figure 5) is recommended. Note that a reuse factor of 3 is an appropriate trade off set point between a low spectrally efficient case of reuse = 7 -- where the throughput gain is minimal if AAS is used and the probability of outage is small in the absence of AAS -- and a high spectrally efficient case of reuse = 1 -- where the throughput gain is considerable when AAS is used and the probability of outage is large in the absence of AAS.

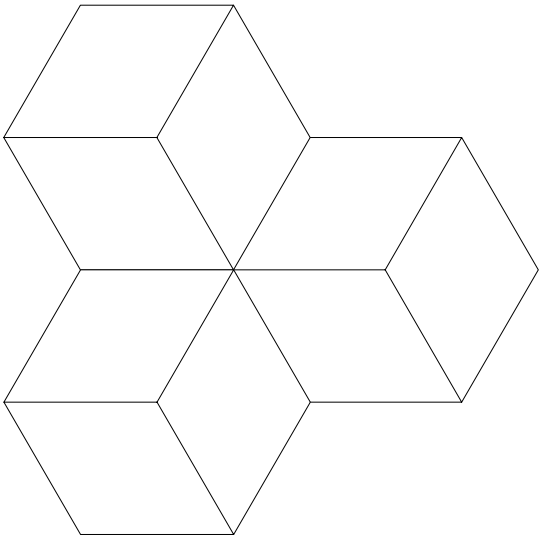

Figure 5. Reuse Factor 3

With this assumption, the minimum required spectrum allocation for appropriate frequency planning would be 15 MHz for systems using 5 MHz channelization and 30 MHz for systems using 10 MHz channelization. A combination of 15 MHz and 30 MHz spectrum allocations could also be considered. Any remaining spectrum from the total available bandwidth can be considered for deployment of single frequency systems (reuse factor 1) based on 5 or 10 MHz bandwidths.

References

[1] Consultation Paper, "DEPLOYMENT OF WIRELESS BROADBAND TECHNOLOGIES IN SINGAPORE," 2 April 2004.
[2] WP8F, updated recommendation M.1036, "Frequency arrangements for implementation of the terrestrial component of International Mobile Telecommunications-2000 (IMT-2000) in the bands* 806-960 MHz**, 1710-2025 MHz, 2110-2 200 MHz and 2500-2690 MHz."
[3] CEPT/ECC/PT1, the development of the ECC Decision on the 2.6 GHz channeling arrangement.
[4] US FCC, Notice of Proposed Rule Making in the matter of Amendment of Parts 1, 21, 73, 74 and 101 of the Commission's Rules to Facilitate the Provision of Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150-2162 and 2500-2690 MHz Bands.
[5] IEEE P802.16-REVd/D4-2000, "Draft IEEE Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed Broadband Wireless Access Systems," March 2004.
[6] ETSI EN 301 021 V1.6.1 (2003-02), "Fixed Radio Systems; Point-to-multipoint equipment; Time Division Multiple Access (TDMA); Point-to-multipoint digital radio systems in frequency bands in the range 3 GHz to 11 GHz."
[7] ITU-R M.2030, "Coexistence between IMT-2000 TDD and FDD radio interface technologies within the frequency range 2 500-2 690 MHz operating in adjacent bands and in the same geographical area."
[8] ITU-R M.[IMT.MITIGATION], "Mitigating Techniques To Address Coexistence Between IMT-2000 Time Division Duplex And Frequency Division Duplex Radio Interface Technologies Within The Frequency Range 2500-2690 MHz Operating in Adjacent Bands and in the Same Geographical Area."