



**CONSULTATION PAPER ISSUED BY THE
INFO-COMMUNICATIONS DEVELOPMENT AUTHORITY OF SINGAPORE**

**SPECTRUM FRAMEWORK FOR FOURTH GENERATION (4G)
MOBILE COMMUNICATION SYSTEMS IN SINGAPORE**

29 March 2010

PART I: INTRODUCTION

**PART II: SPECTRUM ALLOCATIONS FOR 4G MOBILE SERVICES IN
SINGAPORE**

PART III: TECHNICAL QUERIES ON THE 2.5 GHz BAND AND 2.3 GHz BAND

**PART IV: ALLOCATION PROCEDURE AND TIMEFRAME FOR THE 2.5 GHz
BAND AND 2.3 GHz BAND**

PART V: ROLLOUT AND USE OBLIGATIONS

PART VI: INVITATION TO COMMENT

PART I: INTRODUCTION

1 The deployment of 3rd Generation (“3G”) mobile communication systems has brought about a paradigm shift in mobile communications. 3G systems have enabled the launch of high-speed data services that have in turn contributed to changing mobile consumption habits, with services now expanding beyond voice calls to including enhanced services such as mobile broadband and multimedia content. Consumers demand and expectations for mobile broadband services are expected to increase as they become more accustomed to high speed access with fixed broadband services. In Singapore, we are likely to see an even steeper increase in demand for higher speed mobile broadband services with the nationwide deployment of the Next Generation Nationwide Broadband Network by 2012.

2 The next stage is now underway globally for the introduction of next generation ultra high-speed mobile communication system – the 4th Generation or 4G mobile communication system – that will offer end users higher data rates and shorter latency. Mobile technologies capable of delivering performances in line with market expectations have already been announced. Amongst them, LTE (Long Term Evolution) and mobile WIMAX (Worldwide Interoperability for Microwave Access) have received the most attention. Capable of achieving peak data rate in excess of 100Mbps and offering better users’ experience and quality of service over existing 3G systems, LTE and mobile WIMAX are frequently cited as candidate technologies for 4G mobile communication systems.

3 Globally, regulators are looking at ways to free up more radio-frequency spectrum for 4G deployment and two bands are of particular interest – the 690-862 MHz (“700/800 MHz” band) in the UHF band, and the 2500-2690 MHz (“2.5 GHz” band).

4 The 700/800 MHz band is typically allocated for terrestrial broadcast services. With the planned analogue TV switch-off this will free up valuable spectrum which could be used for wireless services. The UHF band is attractive because it has good propagation properties and can therefore provide broad coverage. In the US, the FCC auctioned a total of 108 MHz spectrum in the 700 MHz band in Jan 2008, paving the way for the deployment of high-speed wireless networks using the 700 MHz band.

5 The 2.5 GHz band (also known more commonly as the “2.6 GHz band” in Europe) has been globally harmonised at the World Radiocommunications Conference (“WRC”) in 2000 for the implementation of the International Mobile Telecommunications (“IMT”) standard. In Europe, the Electronic Communications Committee (“ECC”) of the European Conference of Postal and Telecommunications Administrations (“CEPT”) further defined a frequency allocation plan for this band in its Decision ECC/DEC/(05)05 dated 18 March 2005. More recently, the European Commission harmonised the 2.5 GHz frequency band for terrestrial systems through its Decision 2008/477/EC dated 13 June 2008 which specified the technical conditions for using the 2.5 GHz frequency band.

6 Similar to the 2.5 GHz band, the 2300-2400 MHz (“2.3 GHz band”) has also been identified at the WRC 2007 for the implementation of the IMT standard.

7 IDA understands that a common technical standard for 4G system has yet to be agreed upon internationally. In addition, the 700/800 MHz and the 2.3 GHz/2.5 GHz bands are unlikely to be available for assignment in Singapore before 2015. The availability of the 700/800 MHz band is dependent on spectrum coordination with neighbouring countries and their timeline for analogue TV switch-off. The 2.3 GHz and 2.5 GHz bands have been assigned in 2005 and the existing spectrum rights will expire only in 2015. Nonetheless, IDA recognises the increasing global interest in 4G technologies. IDA is assessing the development so as to prepare and facilitate the deployment of 4G systems in Singapore that will be able to meet end users’ increasing mobile communication needs beyond 2015.

Question 1

IDA invites views and comments on the projected spectrum requirements to meet end users’ demand for mobile broadband beyond 2015. To what extent can the existing wireless and mobile networks support the anticipated increase in mobile traffic?

IDA also invites views and comments on the likely technologies for the deployment of 4G mobile communication system that will meet end users’ mobile communication needs beyond 2015.

PART II: SPECTRUM ALLOCATIONS FOR 4G MOBILE SERVICES IN SINGAPORE

8 In Singapore, IDA has progressively made available spectrum for the provision of wireless and mobile services. To-date, IDA has assigned long-term spectrum rights in the 880-915 MHz/925-960 MHz (“900 MHz band”), the 1710-1785 MHz/1805-1880 MHz (“1800 MHz band”), the 1920-1980 MHz/2110-2170 MHz (“2.1GHz band”), the 2.3 GHz and the 2.5 GHz bands. The 900 MHz and 1800 MHz bands were recently re-allocated in 2008 for the provision of public cellular mobile telecommunication services (“PCMTS”) and the spectrum rights will expire in 2017. In the re-allocation, the bands have been opened up for the provision of 2G and 3G technologies and other technologies which share a similar platform and allow higher speed data services to be deployed in the bands, as long as the spectrum is used for the provision of PCMTS. The 2.1 GHz band has been allocated for the provision of 3G services and the spectrum rights will expire in 2021. One 3G spectrum lot in the 2.1 GHz band remains unassigned today and IDA is separately consulting the industry on the demand and method of allocation (refer to IDA’s consultation on “Allocation of 3G Spectrum in the 1900/2100 MHz Frequency Band”).

9 The 2.3 GHz and 2.5 GHz bands have been allocated for the provision of wireless broadband access (“WBA”) services in 2005 and the spectrum rights will be expiring on 30 Jun 2015. In light of the emerging 4G technologies and growing demand for frequency spectrum to meet end users’ needs for higher access speeds, IDA has received queries from the industry as to the availability of the 2.3 GHz and 2.5 GHz bands after 2015 so that they may prepare their business plans with greater certainty.

10 As the agency responsible for the management and allocation of the radio frequency spectrum resource in Singapore, IDA's policy objective is to ensure the most efficient use of our scarce spectrum resources to promote innovation in and growth of a vibrant infocomm industry in Singapore. In this regard, IDA is mindful that the uncertainty surrounding the availability of the 2.3 GHz and 2.5 GHz bands after 2015 may discourage interested operators from aggressively rolling out wireless networks and offering innovative services to the benefit of end-users. IDA therefore considers it appropriate to commence the review of the allocation of the 2.3 GHz and 2.5 GHz bands early, so as to enable the industry to plan ahead.

11 This consultation is primarily focused on seeking the views and comments of the stakeholders and the public on the technology and market trends for the 2.3 GHz and 2.5 GHz bands as well as IDA's proposed approach to make available the 2.3 GHz and 2.5 GHz bands for 4G mobile communication services after 2015. IDA intends to separately consult on the possible use of the 700/800 MHz band when ready.

Question 2

IDA invites views and comments on the possible radio-frequency spectrum bands, besides the 700/800 MHz, 2.3 GHz and 2.5 GHz bands, that would be suitable for 4G mobile communication systems and the likely timeframe for deployment. To what extent are the 900 MHz, 1800 MHz and 2.1 GHz alternative bands for 4G deployment? Are there other frequency bands that are currently not allocated but could be potential candidates for 4G system deployment?

PART III: TECHNICAL QUERIES ON THE 2.5 GHz BAND AND 2.3 GHz BAND

TECHNICAL QUERIES ON THE 2.5 GHz BAND

Technologies for the 2.5 GHz band

12 IDA understands that the LTE and mobile WiMAX are the two candidate technologies for the implementation of 4G mobile communication systems in the 2.5 GHz band. Technically, these mobile technologies can operate in the same spectrum so long as the equipment conforms to internationally recognised technical standards and that appropriate regulatory framework is established to govern use of spectrum.

13 Several countries in Europe, such as Norway, Sweden and Finland, have already auctioned the 2.5 GHz band for mobile services. Similar auctions are planned to take place in the Netherlands, Germany, Austria and the UK in the next two years. Hong Kong recently auctioned the spectrum for the provision of Broadband Wireless Access services. The results of the overseas' auction shows a strong demand for frequency spectrum in the 2.5 GHz band, in particular for the paired spectrum. To-date, TeliaSonera has already deployed commercial 4G/LTE services in the 2.5 GHz band in Sweden and is planning network rollout in Norway and Finland in 2010¹.

¹ www.teliasonera.com/4g/index.htm

14 In Singapore, the amount of spectrum available for assignment in the 2.5 GHz band is based on an interleaved band plan and limited to 90 MHz of spectrum currently. This was the result of coordination with neighbouring countries prior to 2005. Due to Singapore's close geographical proximity to the neighbouring countries, frequency coordination is necessary to avoid frequency interference from foreign networks at the border areas to the Singapore networks, and vice versa. Such frequency coordination activities may sometimes constrain the amount of spectrum that is available for assignment by IDA in Singapore. This is the case with the 2.3 GHz and 2.5 GHz bands where half the band was made available for assignment at the 2005 WBA Spectrum Right Auction as the rest of the frequency bands are susceptible to frequency interference to and from foreign networks. While it is entirely possible for IDA to assign these unallocated frequency spectrum to interested operators, such spectrum assignment is permitted on a non-interference and unprotected basis. This means that Singapore operators must be prepared to operate their networks under the condition that it cannot interfere with the networks of foreign operators at the border areas, and on the understanding that their networks will not be protected from any interference². Due to the interference considerations, these unallocated frequency bands are typically not utilised optimally.

15 Given the increasing interest in the 2.5 GHz band for 4G system deployment, IDA is currently in the process of coordinating with our neighbours for a more efficient usage of the band. In particular, if neighbouring countries are able to agree on the adoption of a harmonised frequency allocation plan for the 2.5 GHz band, this could increase the amount of spectrum available for assignment in Singapore as technical measures can be put in place to reduce interference in border areas. This would require reforming the existing band plan for the 2.5GHz band after 2015.

Question 3

IDA invites views and comments on the demand for the 2.5 GHz band after 2015 in Singapore, and the technologies that are currently being developed for use in the 2.5 GHz band. Are these likely to complement or substitute existing networks? Please also comment on the availability of the network equipment.

Spectrum Channelling Plan in the 2.5 GHz band after 2015

16 Currently, there is no restriction on the underlying technologies to be used for the deployment of WBA services in the 2.5 GHz band. Operators therefore have the flexibility to choose to deploy Frequency Division Duplex ("FDD") or Time Division Duplex ("TDD") wireless broadband technologies in line with IDA's technology-neutral principle. However, operators are expected to coordinate amongst themselves to mitigate the risk of interference on each other's networks.

17 IDA is however mindful that the principle and the extent of technology-neutrality need to be balanced with our objective of ensuring the most efficient usage of the spectrum resource. Under a technology-neutral approach, different operators in

² For more information, see IDA's Information Paper on "Framework for Assignment of Frequencies on Non-Interference and Unprotected Basis" on at www.ida.gov.sg

adjacent bands might choose to use differing technologies. In such a scenario, the co-existence of technologies is a fundamental concern. To mitigate the risk of interference, particularly in the scenario where there is unlikely to be any incentive for the operator of the interfering system to coordinate with the operator whose system is suffering from interference, some amount of guard band may be necessary. This however reduces the amount of usable spectrum. On the other hand, by coordinating the technologies that may be deployed in the band, we could potentially reduce the amount of guard band required, leading to more efficient spectrum usage.

18 For this reason, IDA is of the view that the ECC/DEC/(05)05 Decision where the band is segmented for paired and unpaired spectrum uses strikes a good balance between enabling the coexistence of FDD and TDD systems while minimising undue guard bands needed in this band. Specifically, IDA proposes to divide the 2.5 GHz spectrum into 2 x 70 MHz of paired spectrum, with a 120 MHz duplex spacing and 50 MHz of unpaired spectrum when the band is re-allocated for use after 2015. Beyond this limitation in the usage of the spectrum, IDA will remain technology-neutral and will not prescribe any particular standard for the 4G system deployment. Please refer to Option A of Annex A for details of the band plan.

19 IDA believes that the ECC/DEC/(05)05 Decision provides sufficient flexibility for operators to adopt the appropriate technology that best serve their interest and requirements for deploying island-wide, ultra-fast mobile broadband network by choosing the relevant spectrum. IDA will in turn ensure that the spectrum is made available in a transparent and objective manner when the band is re-allocated.

Question 4

IDA invites views and comments on the paired and unpaired spectrum arrangements in the 2.5 GHz band after 2015.

Guard band

20 To achieve compatibility between FDD and TDD technologies in the 2.5 GHz band after 2015, IDA proposes to set aside 5 MHz guard blocks at the frequency boundaries. This is in line with the 2008/477/EC Decision to have a separation of 5 MHz between the edges of the spectrum blocks to be used for TDD and FDD operations. This also takes into consideration the study by Ofcom, UK that 5 MHz guard blocks will be sufficient to mitigate the risk of adjacent-block interference between FDD and TDD systems when there are appropriate technical measures to control transmissions in the band. IDA intends to establish the technical specifications or measures to be applied to all users in the band subsequently. This will be consulted with the industry and stakeholders separately under IDA's Technical Standards and Advisory Committee.

21 On the other hand, between licensees of unpaired (TDD) or paired (FDD) spectrum, IDA is of the view that there is no need to impose guard blocks as the licensees could co-ordinate among themselves to avoid intra-system interference.

Question 5

IDA invites views and comments on whether the size of 5 MHz guard block at the frequency boundaries between paired and unpaired spectrum is sufficient to safeguard the adjacent band. IDA also invites views on our proposal not to specify guard block requirement between licensees using the TDD or FDD band.

Spectrum Block Size

22 For a nation-wide deployment of a 4G network with present technology, IDA assesses that each operator would need a minimum of 30 MHz to achieve access speed of up to 100 Mbps for a coverage area. This spectrum requirement takes into consideration existing profile for fixed and mobile WiMAX with a carrier size of 5 MHz or 10 MHz used for typical deployment as well as the LTE systems which are designed to support flexible carrier bandwidths (i.e. 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz and 20 MHz). In our assessment on the existing and emerging technologies, it is apparent that 5 MHz block would be the most appropriate size to accommodate various technologies and allows for spectrum harmonisation to achieve economies of scale and global roaming.

23 In view of the above, IDA is considering setting the lot size in 5 MHz blocks. This differs from the current band plan where the 2.5 GHz band is allocated in 6 MHz blocks. IDA's proposed approach is to divide the spectrum into 38 blocks of 5 MHz lot size for which operators can benefit through the deployment of spectrally efficient 4G technologies. For those operators who need a larger carrier size for improvements in spectral efficiency and data throughput in the radio links, this can be achieved by combining multiple lots of 5 MHz together.

Question 6

IDA invites views and comments on whether allocating 5 MHz spectrum lot size is appropriate for the current technologies in the 2.5 GHz band. IDA also invites views on our proposal to allocate spectrum in individual blocks of 5 MHz and let operators who need a larger carrier size to combine multiple blocks together. Alternatively, should IDA allocate in larger blocks based on multiples of 5 MHz?

Alternative Band Plan after 2015

24 While IDA notes the ECC/DEC/(05)05 Decision for the 2.5 GHz band, IDA would like to emphasise that spectrum allocation for this band in Singapore is subject to coordination with our neighbouring countries on the adoption of a harmonised band plan to reduce interference issues in border areas. Bearing in mind that this band is already allocated for Broadcast Satellite Services ("BSS") in Indonesia and that different countries may have different needs, IDA is therefore cognizant that the ECC/DEC/(05)05 Decision may not be fully applicable to our local context. The amount of spectrum available to IDA for assignment would then unlikely be significantly greater than what is available today. Taking into consideration the technologies that could be deployed in the band, in the event where only half the band could be made available for allocation after 2015, IDA's view is that an interleaved band plan with a combination of 15 MHz and 20 MHz paired spectrum blocks, and 25

MHz unpaired spectrum block, best provides Singapore operators with the flexibility to deploy the appropriate technology that would serve their needs (see Option B in Annex A). These spectrum would then be allocated in 15 MHz, 20 MHz and 25 MHz contiguous blocks rather than in smaller block sizes of 5 MHz lots to ensure greater efficiency in spectrum usage.

Question 7

IDA invites views and comments on our proposal for an interleaved band plan with combinations of 15 MHz and 20 MHz paired spectrum blocks as well as 25 MHz of unpaired spectrum blocks available for assignment in contiguous block of 15 MHz, 20 MHz and 25 MHz respectively by IDA and whether this would be appropriate.

IDA also invites views and comments on the practical measures that operators would implement to allow coexistence of BSS and mobile services in the same band in the border areas so that more spectrum blocks can be made available.

TECHNICAL QUERIES ON THE 2.3 GHz BAND

25 Unlike the 2.5 GHz band where overseas' experience shows stronger demand for the paired spectrum, the 2.3 GHz band appears to be favoured for the deployment of TDD networks, with WiMax being the leading technology for deployment. The 3GPP (3rd Generation Partnership Project) has also identified the 2.3 GHz band for the deployment of TDD LTE systems. Currently, a total of 50 MHz spectrum in the 2.3 GHz band is assigned for WBA services based on lot sizes of 5 MHz. There is no restriction on the technology (whether TDD or FDD) for deployment in the band. IDA does not see a need to deviate from our current approach to the 2.3 GHz band after 2015. As such, IDA intends to continue to retain the existing channeling plan for the 2.3 GHz band (see Annex B) with no further restrictions on the underlying technologies for 4G deployment in the band when the band is available for re-allocation after the existing spectrum rights expire. Similar to Option A for the 2.5 GHz band, IDA intends to allocate the 2.3 GHz band in individual blocks of 5 MHz lots and let operators who require larger carrier size to combine multiple blocks together.

Question 8

IDA invites views and comments on the likely technologies for the 2.3 GHz band and the availability of network equipments for use in the band. IDA also invites views on our proposal to retain the existing channeling plan for the 2.3 GHz band and to allocate the spectrum in blocks of 5 MHz when the band is re-allocated after 2015. Please also comment on whether the current amount of 50 MHz spectrum available in the 2.3 GHz band is sufficient to meet industry demands after 2015.

PART IV: ALLOCATION PROCEDURE AND TIMEFRAME FOR THE 2.5 GHZ BAND AND 2.3 GHZ BAND

Spectrum Allocation Timeframe

26 IDA is concerned that operators may be discouraged from investing in network rollout in the 2.3 GHz and 2.5 GHz bands due to lack of investment certainty given that the WBA spectrum right will be expiring on 30 Jun 2015. To provide industry with greater certainty over the availability of the spectrum after 30 Jun 2015, IDA is therefore considering allocating the spectrum in the 2.3 GHz and 2.5 GHz bands earlier. The re-allocation of spectrum for both bands could take place at the same time, once spectrum coordination on the 2.5 GHz band is completed. This could be as early as 2012. Alternatively, IDA may choose to allocate the spectrum separately, and allocate the spectrum in the 2.3 GHz band first.

27 IDA is however mindful that an early allocation could expose operators to greater risk since they would need to plan up to 3 years in advance. This risk that operators will need to undertake is further increased as access to the spectrum is likely to be accompanied with rollout commitments which are described more in detail in the next section.

Question 9:

IDA invites views and comments on what is an appropriate timeframe for IDA to allocate the 2.3 GHz and 2.5 GHz bands. Should the allocation of the 2.3 GHz band proceed separately from that of the 2.5 GHz band, given the greater uncertainty over the timeframe in which the 2.5 GHz band would be available? If so, when would be an appropriate timeframe for IDA to allocate the 2.3 GHz band?

Spectrum Allocation Procedure

28 IDA believes that the market-based approach of allocating spectrum via auction is a fair and transparent way to allow the market to value the spectrum which is a scarce and finite resource. In addition, by allowing spectrum right holders to trade their spectrum, subject to IDA's approval, IDA is of the view that the market-based approach generally encourages more efficient usage of the spectrum.

29 Nonetheless, IDA is mindful that the market-based allocation mechanism may run a risk of disrupting existing service, leading to inconvenience to end-users. It is therefore important to strike a balance between incentivising operators to value the spectrum correctly, and ensuring continuity of services that are being provided. IDA has sought to achieve that balance. For instance, in the re-allocation of the 900 MHz/1800 MHz spectrum in 2008, IDA had decided to re-allocate the 2G spectrum through an auction process to ensure the most efficient use of the scarce spectrum resources. However, to avoid unnecessary spectrum churning to minimize service disruptions and costs, IDA had incorporated an element of "first rights of refusal" for the incumbent holders of 2G spectrum rights, as part of the allocation process.

30 IDA does not rule out the option of adopting a similar approach for the re-allocation of the 2.3 GHz and 2.5 GHz bands should it be assessed that there is a high risk of service disruptions due to spectrum churning.

Question 10:

IDA invites views and comments on what would be a fair and efficient allocation mechanism for the 2.5 GHz band. In the case where there are existing deployments in the band, should IDA grant first rights of refusal for the current right-holders?

PART V: ROLLOUT AND USE OBLIGATIONS

31 IDA's policy objective with allocating the 2.3 GHz and 2.5 GHz bands for 4G mobile communication systems after 2015 is to encourage the deployment of ultra high-speed wireless networks and to promote greater innovation in the infocomm industry. Further, as the agency responsible for the allocation and management of radio frequency in Singapore, IDA has the responsibility to ensure that our scarce spectrum resource is utilised efficiently. As such, IDA considers it reasonable to impose rollout obligations on operators that would be assigned the spectrum, to ensure that the spectrum assigned is put to productive use. Such rollout obligations may take the form of service provisioning and/or coverage obligations.

32 Service Provisioning. Under a service provisioning obligation, operators would be required to rollout service within a specified timeframe. This was done in the WBA spectrum right auction, where WBA operators were required to provide publicly available WBA telecom service to end users within 24 months from award of spectrum right in the 2.5 GHz band, and 36 months from award of spectrum right in the 2.3 GHz band.

33 Service Coverage. Under a coverage obligation, operators would be required to achieve minimum service coverage within a specified timeframe. In general, coverage obligation could be expressed as a percentage of population or as the surface area covered, by one or several services. For instance, the coverage obligation was imposed on 3G operators to rollout nationwide 3G systems and services by 31 December 2004. The measurement criteria used for nationwide service coverage was at least 95% of street-level 3G radio coverage on the island of Singapore, using a signal strength of $\geq -100\text{dBm}$.

34 Given IDA's objective for allocating spectrum in the 2.3 GHz and 2.5 GHz bands after 2015, and considering that technologies for the 2.3 GHz and 2.5 GHz bands are fairly mature today, IDA considers that a combination of service provisioning and coverage obligations to be imposed on the eventual spectrum right holder operators would be reasonable.

Question 11:

IDA invites views and comments on the proposal to impose both service provisioning and coverage obligations on the operators awarded the 2.3 GHz and 2.5 GHz spectrum after 2015. In particular, what would be an appropriate service provisioning obligation and the timeframe for deployment bearing in mind that the spectrum assignment is likely to take effect only from 1 July 2015? Similarly, what would be an appropriate measure for service coverage obligation and the timeframe for deployment?

PART VI: INVITATION TO COMMENT

35 IDA would like to seek the views and comments from the industry and members of the public on the matters stated in the above paragraphs. This will allow IDA to have a better understanding of the issues at hand before issuing its decision.

36 All views and comments should be submitted in writing and in both hard and soft copies (Microsoft Word Format), and should reach IDA by **12 noon, 7 Jun 2010**. Respondents are required to include their personal or company particulars, correspondence address, contact number and email address in their submissions. IDA will make all or parts of any submissions made in response to this consultation paper public and disclose the identity of the source. Any part of the submission which is considered commercially sensitive must be clearly marked and placed as an annex to the comments raised. IDA will take this into account in its review. All comments should be addressed to:

**Aileen Chia (Ms)
Assistant Director General (Telecoms & Post)
Infocomm Development Authority of Singapore
8 Temasek Boulevard
#14-00 Suntec Tower Three
Singapore 038988**

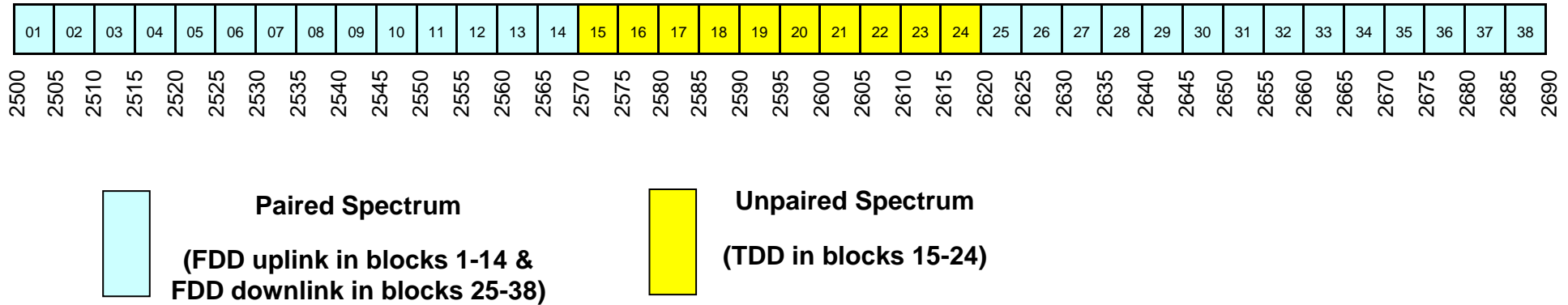
Fax: (65) 6211 2116

AND

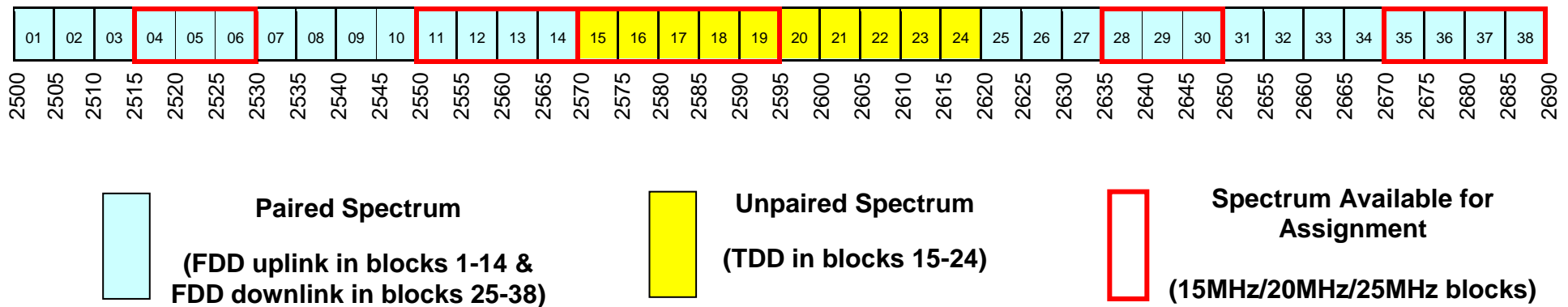
Please submit your soft copies via email to IDA_Consultation@ida.gov.sg

POSSIBLE CHANNELLING PLAN FOR THE 2.5GHz BAND AFTER 2015

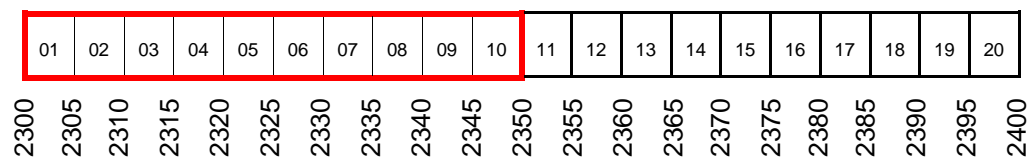
Option A



Option B



POSSIBLE CHANNELLING PLAN FOR THE 2.3GHz BAND AFTER 2015



**Spectrum Currently Available
for Assignment**

(Technology neutral blocks)