



**CONSULTATION PAPER ISSUED BY THE
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**PROPOSED FRAMEWORK FOR THE REALLOCATION OF SPECTRUM FOR
FOURTH GENERATION (“4G”) TELECOMMUNICATION SYSTEMS AND
SERVICES**

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PART I: INTRODUCTION

1 Global mobile data traffic grew three times in 2010 compared to 2009 due to the accelerated adoption of smart phones and tablets. This has brought about a paradigm shift in mobile communications which has seen an evolution from mainly voice communication and text messaging to high data demand services such as Internet surfing, online gaming, online music or video streaming and social networking. The exponential increase in data traffic has highlighted the need for increased mobile data capacity in cellular mobile networks.

2 In the ITU report M.2072, it was predicted that the total worldwide mobile data traffic would grow from around 450 Petabytes in 2008 to around 1,000 Petabytes in 2015 with a Compound Annual Growth Rate (CAGR) of 12%¹. IDA has conducted its own internal assessment and forecasts that the mobile data traffic in Singapore would grow exponentially from around 3.1 Petabytes per month in 2010 to around 37 Petabytes per month in 2015², representing a CAGR of 64%.

3 To manage the growth of mobile data traffic, mobile operators have adopted several approaches including tiered pricing³, traffic policy management control⁴, network optimisation, upgrading of existing infrastructure, adoption of new technologies such as Long Term Evolution technology (“LTE”, which is commonly referred to as a ‘4G’ technology) and mobile data offloading⁵ strategies.

4 Complementing the efforts of local mobile operators to manage the projected growth in data traffic, IDA recognises the need for operators to have access to sufficient radio-frequency spectrum to increase network capacity. This consultation paper consults members of the industry and the public on the parameters for the reallocation of spectrum for 4G telecommunication services in Singapore.

Existing spectrum allocation

5 Spectrum in the 2.3 GHz and 2.5 GHz frequency bands has been allocated for the provision of Wireless Broadband Access (“WBA”) services in Singapore under the

¹ ITU-R M.2243 “Assessment of the global mobile broadband deployments and forecasts for International Mobile Telecommunications”.

²Other studies supporting the exponential growth in mobile data traffic are cited below:

Cisco projected that “[g]lobal mobile data traffic will increase 26-fold between 2010 and 2015”, growing at a compound annual growth rate of 92 percent from 2010 to 2015 (source: http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html).

Ericsson predicted that “mobile data traffic will grow 10-fold between 2011 and 2016” (source: <http://www.ericsson.com/news/1561267?idx=50>).

Nokia Siemens Networks estimated that, within a decade, there would be “ten times more mobile broadband users, each using 100 times more data” (source: <http://www.nokiasiemensnetworks.com/news-events/publications/unite-magazine-issue-10/10-x-10-x-10-the-formula-for-beyond-4g>).

³ Tiered pricing is the practice of charging subscribers according to how much bandwidth they consume.

⁴ The 3GPP Technical Specification TS 29.209 defines the protocols for the heart of policy control over the Gq interface between the Policy Decision Function (PDF) and the Application Function (AF). Policy control offers operators greater control over service provisioning and network resource management.

⁵ Mobile data offloading is the use of complementary network technologies (e.g. Femtocell or Wi-Fi) for delivering data originally targeted for cellular networks.

respective WBA Spectrum Rights. The “2.3 GHz band” refers to the spectrum band from 2300 MHz to 2400 MHz while the “2.5 GHz band” (also known more commonly as the “2.6 GHz band” in Europe) refers to the spectrum band from 2500 MHz to 2690 MHz.

6 Based on IDA’s current Spectrum Rights Assignments plan, WBA Spectrum Rights have been assigned to QMax Communications Ltd (“**QMax**”) to use spectrum in the 2.3 GHz band, and to M1 Limited (“**M1**”), Packet One (S) Pte Ltd (“**P1**”), SingTel Mobile Pte Ltd (“**STM**”) and StarHub Ltd (“**StarHub**”) to use spectrum in the 2.5 GHz band, collectively – the “WBA operators”. Specifically, the spectrum assignments are as follows:

Frequency	Assignment
2300 MHz – 2330 MHz	QMax
2330 MHz – 2350 MHz	QMax
2516 MHz – 2528 MHz	M1
2540 MHz – 2552 MHz	STM
2564 MHz – 2576 MHz	P1
2576 MHz – 2588 MHz	StarHub
2588 MHz – 2600 MHz	P1
2636 MHz – 2648 MHz	M1
2660 MHz – 2672 MHz	STM
2672 MHz - 2678 MHz	P1

7 The WBA Spectrum Rights were granted to the WBA operators on 1 July 2005⁶, and will expire on 30 June 2015. In addition, under IDA’s “Framework for Assignment of Frequencies on Non-Interference and Unprotected Basis” published by IDA on 8 March 2010, IDA has administratively assigned some of the constrained frequencies⁷ in the 2.5 GHz band to various operators.

8 Besides spectrum in the 2.3 GHz and 2.5 GHz frequency bands, spectrum in the 1800 MHz band may also be used for the provision of data services, including WBA, using technologies such as LTE. The “1800 MHz band” refers to the paired spectrum bands from 1710 MHz to 1785 MHz and 1805 MHz to 1880 MHz

9 In Singapore, spectrum in the 1800 MHz band has been assigned to STM, StarHub Mobile Pte Ltd (“**StarHub Mobile**”) and M1 through the Public Cellular Mobile Telecommunication Services (“**PCMTS**”) Spectrum Rights, 1800 MHz Spectrum Right and 1800 MHz Spectrum Right (2011), all of which will expire on 31 March 2017. The specific spectrum assignments are listed in the following table:

Paired Frequency		Assignment
Lower band (MHz)	Upper Band (MHz)	
1710 – 1715	1805 - 1810	STM
1715 – 1720	1810 – 1815	StarHub Mobile
1720 – 1725	1815 – 1820	STM

⁶ The WBA Spectrum Rights were originally awarded to Pacific Internet Corporation Pte Ltd and Inter-touch Holdings (Singapore) Pte Ltd in 2005. However, in 2009, through spectrum trading arrangements, these rights were subsequently traded to P1 and QMax respectively.

⁷ Constrained frequencies are frequencies that have not been assigned for priority access by Singapore operators. In the 2.5 GHz band, the constrained frequencies are as follows: 2500 MHz to 2516 MHz, 2528MHz to 2540 MHz, 2600 MHz to 2636 MHz and 2648 MHz to 2660 MHz.

1725 – 1730	1820 – 1825	STM
1735 – 1740	1830 – 1835	STM
1740 – 1745	1835 – 1840	StarHub Mobile
1745 – 1750	1840 – 1845	StarHub Mobile
1750 – 1755	1845 – 1850	StarHub Mobile
1755 – 1760	1850 – 1855	StarHub Mobile
1760 – 1785	1855 – 1880	M1

Earlier consultations on 4G mobile communication systems

10 In June 2010, IDA issued a consultation paper on the “Spectrum Framework for 4G Mobile Communication Systems in Singapore”, seeking views 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.

11 IDA, in its Interim Decision of 24 January 2011 on that consultation, agreed that early allocation of the 2.3 GHz and 2.5 GHz bands will provide more certainty to market participants, and would seek to provide more clarity over the spectrum coordination process and the timeframe for re-allocation of the bands as early as 2012.

12 With regard to the definition of 4G, IDA noted in its Interim Decision that only LTE-Advanced and WiMAX 2 (to be known as WirelessMAN-Advanced) have been established by the ITU as meeting IMT-Advanced specifications (commonly referred to as 4G technologies). However, the ITU has not disputed the likelihood that LTE and WiMAX, forerunners of the LTE-Advanced and WiMAX 2 technologies respectively, may also be recognised as 4G technologies as they provide a substantial level of improvement in performance and capabilities with respect to 3G systems. IDA further noted that its consultation confirmed strong interest in deploying LTE and WiMAX systems for the provision of wireless broadband services in the 2.3 GHz and 2.5 GHz bands to meet end users’ mobile communication needs going forward. IDA therefore concluded that it was “*prepared to allow the deployment of 4G technologies including LTE and WiMAX and their advanced versions in the 2.3 GHz and 2.5 GHz bands when the bands are re-farmed and reallocated*” (as discussed in paragraph 36 below).

13 In the same Interim Decision, IDA also clarified that “*operators may choose to deploy WiMAX or LTE or their advanced versions under their existing WBA spectrum rights as long as the spectrum is used for any part of a WBA network that provides publicly available WBA telecom services to end-users*”, and that “*consistent with IDA’s position on use of the 900 MHz/1800 MHz spectrum, IDA will not prohibit operators from deploying LTE in the bands as long as operators meet the requirement to provide PCMTS using the bands*”, subject to certain conditions being met.

14 Since IDA’s policy clarification in the Interim Decision, some operators in Singapore that have been assigned spectrum rights in the 2.3 GHz, 2.5 GHz and 1800 MHz bands have either begun to, or announced their intention to, deploy LTE systems and services to end users using their existing spectrum assignments. Given strong industry interest in the early re-allocation of the 2.3 GHz and 2.5 GHz spectrum bands for 4G mentioned in IDA’s Interim Decision, and to give greater business certainty to operators that have, or are planning to invest in 4G systems and services,

IDA is preparing to re-allocate the relevant spectrum bands to enable and encourage investment in 4G systems and the provision of 4G services to members of the public.

PART II: AVAILABLE SPECTRUM

Spectrum bands to be re-allocated

15 As highlighted above, mobile operators have multiple options to cater for the growth in demand for mobile data, including increasing the capacity of their networks to handle mobile data traffic. Some options to manage the increase in data traffic include deploying new systems and services like 3G and 4G in spectrum bands traditionally used for other types of systems and services like 2G. In relation to the use of spectrum, given existing technology trends, mobile operators may also deploy technologies such as Cognitive Radio that can enable flexible spectrum management.

16 In the assignment and use of spectrum for 4G deployments, some regulators internationally have made a distinction between sub-1 GHz spectrum which tend to provide better geographical coverage for the same number of sites given the better propagation characteristics of low frequency spectrum, and spectrum above 1 GHz. For example, the UK's Office of Communications ("**Ofcom**") stated in its "*Assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues*"⁸ of March 2011 that spectrum in the 800 MHz bands was "*key to the economic delivery of next generation mobile broadband services in less densely populated areas*". Ofcom further added that the 800 MHz band was "*ideal for wide-spread and indoor mobile coverage*" whilst the 2.6 GHz band was "*ideal for delivering the capacity needed to deliver higher speeds and provide services simultaneously to many users*". Hence the "*combination of low and high frequency spectrum creates the potential for next generation mobile broadband services to be widely available across the UK, while at the same time having the capacity to cope with significant demand, even in urban centres*".

17 In Singapore's context, it is unlikely that spectrum in the 700 MHz (698 MHz to 862 MHz) band, which has been assigned in various international jurisdictions for 4G deployment, will be made available for allocation for mobile systems and services in the next few years. At this juncture, regional co-ordination on the re-farming and use of the 700 band is still ongoing. While IDA notes industry's interest in the 700 MHz band from IDA's 2010 consultation on 4G, IDA is unlikely to be able to make available spectrum in the 700 MHz band for allocation together with spectrum from the 2.3 GHz and 2.5 GHz band.

18 Besides spectrum in the 2.3 GHz and 2.5 GHz bands, IDA considered whether to re-allocate spectrum in the 900 MHz and 1800 MHz bands (the "**PCMTS bands**") in the same re-allocation exercise.

19 On one hand, IDA considered that there could be complementarities in the bands, especially between the 1800 MHz band and the 2.3 GHz and 2.5 GHz band. Internationally, jurisdictions are beginning to facilitate the use of PCMTS bands for 3G and 4G deployments. The European Commission, for example, issued a Decision⁹ in April 2011 confirming the technical parameters for the deployment of 4G services with LTE and WiMAX technologies in the PCMTS bands. Since 2008, IDA has also

⁸ <http://stakeholders.ofcom.org.uk/consultations/combined-award/>

⁹ 2011/251/EU: Commission Implementing Decision of 18 April 2011 amending Decision 2009/766/EC on the harmonisation of the 900 MHz and 1800 MHz frequency bands for terrestrial systems capable of providing pan-European electronic communications services in the Community.

allowed 3G deployments in the PCMTS bands subject to certain conditions, and has clarified in its Interim Decision that the PCMTS bands may also be used for 4G deployments subject to conditions. In addition, market developments have also demonstrated complementarities in the bands, with an increasing number of 4G deployments in the 1800 MHz bands being commercially deployed. Even though IDA notes that 4G deployments in the 900 MHz band are more uncommon, the re-farming of the 900 MHz band for 3G data services may also complement the mobile operators' planning of mobile data capacity, especially in the absence of an alternative low frequency band with the constraints of the allocation of the 700 MHz band. With these complementarities, IDA is cognisant that operators may obtain more certainty in future spectrum holdings and network planning if the 2.3 GHz and 2.5 GHz bands were re-allocated in the same exercise as the PCMTS bands.

20 On the other hand, the asynchronous expiry of the WBA Spectrum Rights and spectrum rights assigned in the PCMTS bands might mean that a joint re-allocation exercise would require operators to make investment decisions in the PCMTS bands several years before the expiry of existing spectrum rights. This would be the case especially if IDA re-allocates spectrum in the 2.3 GHz and 2.5 GHz band by late 2012 or early 2013, which would mean that operators would have to decide on their desired spectrum holdings in the PCMTS bands more than four years before the expiry of existing spectrum rights. In addition, de-linking the re-allocation of the 2.3 GHz and 2.5 GHz bands from the re-allocation of the PCMTS bands may provide operators with the option of acquiring sufficient spectrum holdings to launch or continue existing 4G services, while making a more informed decision on the additional spectrum required at a later stage when consumer demand for 4G is more certain. Finally, a later re-allocation of the PCMTS bands would also allow IDA to monitor both technical and commercial 4G developments in the PCMTS bands, which would allow IDA to better develop the framework for re-allocation of the PCMTS bands for 4G usage.

21 Balancing the above considerations, IDA's preliminary position is to make available the 1800 MHz, 2.3 GHz and 2.5 GHz bands in the upcoming re-allocation exercise. IDA notes that, in terms of propagation characteristics, the 1800 MHz, 2.3 GHz and 2.5 GHz bands are suited for urban deployment for mobile data capacity and can be considered substitutes. These are also the bands that are most commonly used for 4G deployments today, besides the 700 MHz band. Releasing the three spectrum bands at the same time for auction will hence allow for more efficient network planning by operators.

22 As for the 900 MHz band, IDA notes that the technology path for the 900 MHz band is currently less certain and equipment currently available for the 900 MHz band is geared towards re-farming of the band for 3G (and not 4G) purposes. Given the almost 2-year time difference between the 2.3 GHz and 2.5 GHz bands and the 900 MHz band being made available, there could be significant uncertainty on the viability of spectrum use in the 900 MHz band for 4G services if the 900 MHz band were to be auctioned together with the remaining spectrum bands. On the other hand, holding back the 900 MHz band would allow both IDA and the industry to monitor technology trends for this band. IDA therefore proposes not to include the 900 MHz band in this current re-allocation exercise.

Question 1

IDA seeks views on the proposed allocation of the 1800 MHz, 2.3 GHz and 2.5 GHz spectrum bands.

Amount of spectrum to be made available

23 IDA recognises the need to make sufficient spectrum available to the industry. At the same time, there is a need for IDA to reserve some spectrum for future needs as well as temporary assignments. Balancing these considerations, IDA intends to make available the following amounts of spectrum in the 1800 MHz, 2.3 GHz and 2.5 GHz spectrum bands:

- a. 1800 MHz band: 140 MHz, comprising 2x70 MHz of paired spectrum given that Frequency Division Duplex (“**FDD**”) technology is more commonly deployed in the band;
- b. 2.3 GHz band: 30 MHz, likely for deployment of Time Division Duplex (“**TDD**”) technology; and
- c. 2.5 GHz band: 150 MHz, comprising 2x60 MHz of paired spectrum and 30 MHz of unpaired spectrum. This proposal is subject to the conclusion of a full-band arrangement with Singapore’s neighbouring countries (as discussed in paragraphs 26 to 30 below). Within the 2x60 MHz, IDA also intends to set aside 2x20 MHz of paired spectrum in the 2.5 GHz band to cater for a possible new entrant in this auction, or for future market entry or expansion. This is further discussed in Part VI of this paper.

24 IDA proposes to reserve:

- a. 2x5 MHz paired spectrum in the 1800 MHz band;
- b. 20 MHz of spectrum in the 2.3 GHz band; and
- c. 2x10 MHz of paired spectrum and 20 MHz of unpaired spectrum in the 2.5 GHz band,

to cater for trial uses for new technologies as well as possible future increases in demand for capacity. The spectrum held in reserve will also be useful to cater for temporary demands for spectrum use (particularly in the 2.3 GHz and 2.5 GHz bands for ‘live’ coverage during national events – this is further discussed in paragraphs 45 to 47 below). In deciding the amount of spectrum to be reserved in each band, IDA also considered that mobile operators would typically require spectrum blocks of about 2x20 MHz (if FDD technology is used) or 20 – 30 MHz (if TDD technology is used) for nationwide network deployment.

25 Diagrams which show the amount of spectrum IDA proposes to auction in the 1800 MHz, 2.3 GHz and 2.5 GHz bands are attached as **Annex A**.

Question 2

IDA seeks views on the amount of spectrum to be made available for allocation in the 1800 MHz, 2.3 GHz and 2.5 GHz bands.

2.5 GHz band – start date for full-band sharing arrangement

26 In the 2.5 GHz band, IDA indicated in its Interim Decision that a full-band sharing arrangement with neighbouring countries was preferred, where operators in each country would be able to utilise spectrum throughout the band with coordination at the borders subject to certain technical parameters. This was also the preference expressed by industry players in IDA’s earlier 4G consultation.

27 IDA has obtained in-principle agreement with our neighbouring countries on the full-band sharing arrangement for the 2.5 GHz band. This means that up to 190 MHz of spectrum in the band could be available for IDA to allocate by way of spectrum right assignments in the upcoming 4G spectrum re-allocation exercise and in the future.

28 Full-band sharing would mean that Singapore operators will be required to coordinate with their counterparts at the border areas on technical parameters such as frequency channel usage and signal strength spillage for use of the 2.5GHz band.

29 At this juncture, the start date for the full-band sharing arrangement has yet to be finalised, although IDA expects the arrangement to be implemented no later than the expiry of existing WBA spectrum rights. In its discussions with the relevant agencies in neighbouring countries on a feasible start date for the full-band sharing arrangement, IDA is aware that existing holders of WBA Spectrum Rights have been assigned their spectrum rights in bands for which Singapore has priority use based on the current half-band sharing arrangement. As mentioned previously, spectrum in the constrained frequencies has also been administratively assigned to several operators.

30 That said, IDA is of the view that an earlier implementation of the full-band sharing arrangement would be beneficial for Singapore operators and the market because:

- a. this would provide more certainty to the industry and more leeway for operators to plan for the utilisation of the band early; and
- b. this would allow for an earlier and potentially smoother transition to commercial launch of services in the band.

Question 3

IDA seeks views on the benefits of an earlier start date for the full-band sharing arrangement, and what an appropriate start date might be.

2.5 GHz band – timing of spectrum availability for spectrum not assigned under existing WBA Spectrum Rights

31 Considering the issues above, if the full-band sharing arrangement for the 2.5 GHz band is implemented before the expiry of the existing WBA Spectrum Rights, it will be possible for IDA to allow spectrum rights assigned to use the bands that are currently the constrained frequencies (“**the new frequencies**”) to commence before 1

July 2015. Spectrum rights assigned to use bands that have already been assigned under existing WBA Spectrum Rights will however only commence from 1 July 2015. Subject to the results of the re-allocation exercise, IDA is prepared to allow the winning bidders of the new frequencies to use the spectrum under the new spectrum right from the start date of the full-band sharing arrangement, or one day after the expiry date of any administrative assignment of the new frequencies, whichever is the later date, subject to the winning bidders ensuring appropriate coordination with their counterparts in neighbouring countries, among others. Nonetheless, any arrangement for winning bidders to commence the use of the relevant spectrum bands early will be subject to terms and conditions imposed by IDA at IDA's discretion. IDA's proposed technical parameters for cross border coordination are discussed in Part VIII of this paper.

Block size and pairing of spectrum blocks

32 As stated in IDA's Interim Decision, industry players have indicated varying preferences on the block size for each spectrum lot to be allocated, ranging from small blocks of 5 MHz (or 5 MHz paired for FDD technology) which provide higher granularity and maximum flexibility for operators to decide on permutations or multiples of 5 MHz, to 10 MHz to 30 MHz on the basis of spectral efficiency considerations as well as considering the block size required to achieve certain desired bandwidths in service offerings.

33 IDA is of the view that 10 MHz would be an appropriate block size per spectrum lot in the re-allocation exercise. Such a block size would allow operators sufficient flexibility to scale up their spectrum holdings in multiples of either 2x5 MHz pairs or 10 MHz given IDA's auction rules (as detailed in Part V of this paper)

34 While IDA intends to maintain a technology neutral stance in the use of the assigned spectrum, i.e., operators may deploy TDD or FDD technologies based on LTE, WiMAX or other standards and technologies, IDA notes that that industry players have expressed support for certain band plans that segment the 2.3 GHz and 2.5 GHz bands in various ways. For the 2.3 GHz band, IDA intends to segment the band based on 10 MHz lots, typical for TDD-type deployments. This means that the 30 MHz of available contiguous spectrum in the 2.3 GHz band will be segmented into three spectrum lots comprising three 10 MHz blocks of spectrum for allocation. For the 2.5 GHz band, IDA intends to segment the band consistent with the ECC/DEC/(05)05 Decision, based on 2x70 MHz of paired spectrum with a 120 MHz duplex spacing and 50 MHz of unpaired spectrum. With IDA keeping 2x10 MHz of paired spectrum and 20 MHz of unpaired spectrum in reserve, IDA intends to make available 12 spectrum lots of 2x5 MHz of spectrum and another three lots of 10 MHz of spectrum available in the 2.5 GHz band for allocation. As for the 1800 MHz band, IDA intends to segment the band based on 2x75 MHz of paired spectrum with a 95 MHz duplex spacing (leaving 2x5 MHz in reserve). This segmentation is also consistent with the current allocation of the 1800 MHz band for PCMTS services.

Question 4

IDA seeks views on the proposed block size per spectrum lot, the number of spectrum lots, and the arrangement of the spectrum lots to be made available for reallocation.

Guard bands

35 In IDA's earlier public consultation, IDA proposed to set aside 5 MHz guard bands at the frequency boundaries between FDD and TDD technologies in the 2.5 GHz band. IDA notes that some other regulators, like Hong Kong's Office of the Telecommunications Authority, have also set aside these guard bands in their spectrum auctions. IDA received mixed feedback in the earlier consultation, with some respondents indicating that there is no need for IDA to impose such guard bands. Rather, licensees could co-ordinate amongst themselves for the co-existence of the different services in adjacent spectrum bands. IDA has re-assessed the matter and is of the view that the set aside of guard bands is not required, given that technical measures such as separation distances or transmission power may be adjusted to mitigate interference. However, licensees will be required to co-ordinate their network deployments for minimal interference.

Question 5

IDA seeks views on its proposal for operators to co-ordinate the use of different services and not to set aside guard bands at the frequency boundaries between FDD and TDD technologies in the 2.5 GHz band.

PART III: ALLOWABLE USES FOR THE SPECTRUM

Definition of “4G”

36 IDA proposes that bidders which successfully bid for the 4G spectrum lots be required to use the spectrum for the provision of 4G services, e.g., mobile data, voice, voice over IP etc, to the public. For this purpose, IDA proposes to define ‘4G’ as:

“An all-IP packet switched cellular mobile communications system capable of evolving to achieve the targeted peak data rates of 100 Mbits/s for high mobility and 1 Gbit/s for low mobility as defined by ITU-IMT-Advanced; meeting at minimum the standards and specifications of either LTE (i.e. 3GPP Release 8), or WiMax (i.e. IEEE 802.16-2009).”

37 This definition is in-line with IDA’s Interim Decision on what constitutes 4G technologies. As mentioned above, IDA will adopt a technology neutral approach and will not prescribe which technologies operators should adopt in the allocated spectrum bands.

38 IDA is aware that there may be other technologies, existing or future, that may not meet the definition of 4G technologies as described above, although the technologies may also be capable of delivering high speed mobile data services to end users. Should operators wish to deploy these technologies in the 4G spectrum lots, IDA will assess such requests on a case-by-case basis, taking into account issues such as the technical interference between these technologies, technologies deployed in regional frequency bands and other relevant considerations.

Question 6

IDA seeks views on its proposed definition of 4G technologies and the proposal to assess on a case-by-case basis alternative technologies to be deployed in the 4G spectrum bands.

PART IV: KEY PROPOSED SPECTRUM RIGHT CONDITIONS

39 Operators granted the 4G spectrum rights will be required to offer commercially available 4G services to retail end users in Singapore using the assigned spectrum. For the avoidance of doubt, commercially available 4G services shall exclude services offered on a trial or similar temporary basis.

40 In addition, recognising that the spectrum resource is limited, IDA is of the view that the 4G spectrum rights will be more effectively used to provide 4G services to all end users, rather than used by operators solely to deploy niche or geographically-limited services. IDA thus intends to require operators granted 4G spectrum rights to provide **nationwide** 4G systems and service coverage by the following dates:

- a. Winning bidders which have either been allocated at least a total of 30 MHz of spectrum in the 2.3 GHz and/or 2.5 GHz bands (whether paired or unpaired) must provide:
 - i. nationwide 4G systems and service coverage (*excluding* MRT underground stations/lines and road tunnels) by 30 June 2016 (i.e., 12 months after the commencement of 4G spectrum rights in the 2.3 GHz and 2.5 GHz bands); and
 - ii. nationwide 4G systems and service coverage in MRT underground stations/lines and road tunnels by 30 June 2018 (i.e., 36 months after the commencement of 4G spectrum rights in the 2.3 GHz and 2.5 GHz bands).
- b. All other winning bidders, i.e., winning bidders which have been allocated spectrum in the 1800 MHz band and less than 30 MHz of spectrum in the 2.3 GHz and/or 2.5 GHz band must provide:
 - i. nationwide 4G systems and service coverage (*excluding* MRT underground stations/lines and road tunnels) by 31 March 2018 (i.e., 12 months after the commencement of 4G spectrum rights in the 1800 GHz band); and
 - ii. nationwide 4G systems and service coverage in MRT underground stations/lines and road tunnels by 30 June 2020 (i.e., 36 months after the commencement of 4G spectrum rights in the 1800 GHz band).

The term “nationwide 4G system and service coverage” shall mean that the licensees must be able to provide 4G coverage throughout the whole of the island of Singapore (including but not limited to MRT underground stations/lines and road tunnels), the offshore islands and the territorial waters up to 15km from the coast line of the island of Singapore.

41 For the avoidance of doubt, IDA is prepared to allow the licensees granted 4G spectrum rights to share infrastructure or deploy their infrastructure across different frequency spectrum bands to deploy 4G services nationwide. However, any such

infrastructure or spectrum sharing arrangements must be submitted to IDA for approval.

42 Given Singapore's geography, and the typical system build-out time, IDA believes that the proposed deadlines are reasonable.

43 Notwithstanding the above, IDA is prepared to grant new entrants, who are currently not providing nationwide mobile services in Singapore, a longer lead time to complete the roll-out requirements. This is in consideration that more time may be needed, e.g., to secure the necessary sites for infrastructure deployment. Further discussions on the possible special conditions that may be afforded to new entrants can be found in Part VI of this paper.

44 Operators should note that IDA reserves the right to impose minimum quality of service standards on 4G services to ensure that service standards meet consumer expectations, especially with the expected exponential growth of mobile data traffic.

Question 7

IDA seeks views on its proposal that successful bidders of 4G spectrum should meet nationwide 4G systems and service coverage requirements by the dates specified.

Spectrum Co-ordination during National Events

45 As the industry may be aware, during national events such as the Formula One ("F1") races, the National Day Parade and Chingay in Singapore IDA may make arrangements to coordinate between various spectrum holders to cater to the spectrum needs of the event organiser. For example, during the F1 races, there is significant demand by the event organiser for potentially 1 GHz of spectrum in total, including spectrum in the 1800 MHz, 2.3 and 2.5 GHz spectrum bands for uses such as wireless high-definition cameras. Currently, IDA's arrangements are to facilitate negotiations between the spectrum rights holders and the parties who have temporary spectrum use demands with a view of allowing both parties to reach a commercial settlement for use of the spectrum.

46 As IDA is proposing to allocate most of the spectrum in the 1800 MHz, 2.3 and 2.5 GHz spectrum bands, there may be situations where IDA will need to temporarily re-allocate the 4G spectrum bands allocated to spectrum rights holders in order to meet the short-term demands for national events. IDA will therefore also include a condition, as part of the 4G spectrum right award, that allows IDA to re-allocate on a temporary basis, spectrum required to support national events.

47 IDA recognises that such situations may cause disruptions in the provision of end user services by operators. As far as possible, IDA will work with the affected spectrum rights holders in advance of the event, to coordinate the temporary spectrum use. IDA is also prepared to work with operators on joint publicity to educate consumers on the possible disruptions to their 4G services during such national level events.

PART V: PROPOSED AUCTION FORMATS

48 IDA believes that the market-based approach of allocating spectrum is a fair and efficient method to allocate a scarce and finite resource, by allowing the market to value the spectrum. Given the significant interest in the 4G spectrum rights, IDA is of the view that conducting an auction to allocate the 4G spectrum lots will ensure that the spectrum resource is allocated in the most efficient and transparent manner.

49 IDA proposes the following parameters for the auction:

- a. **Duration of the spectrum right.** IDA proposes to assign the 1800 MHz, 2.3 GHz and 2.5 GHz spectrum up till **30 June 2030**. Accordingly, spectrum allocated in the 2.3 GHz and 2.5 GHz spectrum bands will be made available for a period of 15 years, while spectrum in the 1800 MHz band will be made available for approximately 13 years.

Given the speed of technological innovation, IDA notes that there is a need to ensure that spectrum is available and re-farmed to cater for new requirements in the future. Nonetheless, IDA recognises that operators will need significant investments to rollout 4G services. Hence, on the balance, IDA believes that the proposed licence period of 13 to 15 years strikes the right balance. Ensuring the spectrum rights in the 1800 MHz, 2.3 GHz and 2.5 GHz bands expire on the same date also facilitates IDA's planning for future spectrum right assignments.

- b. **Auction Format.** IDA is considering a variant of the Simultaneous Multiple Round Action ("**SMRA**") and Combinatorial Clock Auction ("**CCA**") formats commonly used in 4G auctions conducted overseas. A general description of the two auction formats can be found in **Annex B**. IDA's proposed "Clock Plus" auction has recently been adopted in Sweden and India for their 4G spectrum auctions.

In the proposed auction format, bidders will specify demand for quantities of lots within specified lot categories (as specified in sub-paragraph c below), subject to the relevant spectrum caps (as discussed in sub-paragraph d below). In each round, there is a single common price for all lots within a category, and this price 'ticks' up over successive rounds until there is no longer any excess demand. A more detailed explanation of the Clock Plus auction can be found in **Annex C**.

IDA believes that the proposed Clock Plus auction format will result in an efficient auction outcome and, like the SMRA and CCA formats, will allow bidders to react to price information during the auction and facilitate price discovery. An advantage of the Clock Plus format is that aggregation risks within categories are eliminated, as a quantity bid within a category is, de facto, a package bid that is accepted or rejected in its entirety. This means that bidders are not exposed to winning unwanted subsets of their demand and can be guaranteed contiguous spectrum within categories. Compared to a CCA, the format is significantly simpler to implement, and there is no requirement for a supplementary round or for complex winner and price determination.

As bidders will be bidding on generic lots within the lot categories, the actual assignment of the spectrum lots will take place during a second stage (with the assignment ensuring that all winning bidders are assigned contiguous lots). In this second stage, IDA will first solicit views from the winning bidders as to whether they have any specific spectrum lot allocation preferences, and whether such preferences differ amongst the winning bidders. If there is a difference in preferences, IDA will set out all possible spectrum lot allocations. The winning bidders will then participate in a sealed bid auction to determine the final allocation of spectrum lots within the category. In this second stage auction, IDA will allocate specific spectrum lots based on the highest value of the combination of bids.

Besides the “Clock Plus” format, IDA is also considering the SMRA format which has been used in IDA’s 2005 auction for WBA Spectrum Rights, and is also commonly adopted by regulators internationally. IDA notes that this may prove to be a simpler auction format, but may result in the situation where bidders are exposed to winning unwanted subsets of their demand, and potentially being allocated non-contiguous spectrum.

- c. **Spectrum lots.** If IDA adopts the Clock Plus auction format, IDA proposes to auction the: (1) 1800 MHz band; (2) FDD spectrum in the 2.5 GHz band; and (3) TDD spectrum in the 2.3 GHz and 2.5 GHz bands as three separate categories.

IDA proposes to auction the spectrum within the three categories as generic lots, in lot sizes of: (1) 2x5 MHz paired spectrum for the FDD spectrum in the 1800 MHz and 2.5 GHz bands; and (2) 10 MHz for TDD spectrum in the 2.3 GHz and 2.5 GHz bands. Given the proposed auction format above, IDA believes that auctioning the 4G spectrum in generic lot sizes of 10 MHz will provide bidders with the necessary flexibility in deciding how much spectrum they would want to bid for. There will be a total of: (1) 14 lots of FDD paired spectrum (i.e., 2x5MHz per lot) in the 1800 MHz band; (2) eight lots of FDD paired spectrum (i.e., 2x5MHz per lot) in the 2.5 GHz band; and (3) six lots of TDD spectrum (i.e., 10MHz per lot) in the 2.3 GHz and 2.5 GHz bands available for auction.

The table below summarises IDA’s proposal:

Category	Lots available	Spectrum range (MHz)	
		Lower Band	Upper Band
1800 MHz	14 x 2x5MHz (total 2 x 70 MHz)	1715 – 1785	1810 – 1880
		2500 – 2560	2620 – 2680
2.5 GHz FDD	8 x 2x5 MHz (total 2 x 40 MHz)		
TDD	6 x 10 MHz (total 60 MHz)	2300 – 2330 and 2570 – 2600	

For the avoidance of doubt, IDA's usage of the terms "FDD spectrum" and "TDD spectrum" are meant to refer to paired and unpaired spectrum respectively. In line with IDA's technology neutral approach, IDA does not intend to limit the actual technology that is deployed within each spectrum lot so long as the technology deployed meets the definition of "4G" as set out in paragraph 36.

- d. **Spectrum Caps.** IDA proposes the following caps for each bidder in the auction: (1) up to 2x45MHz of spectrum in total for both the 1800 MHz and 2.5 GHz FDD categories; and (2) no spectrum cap for the TDD category, excluding the proposed amount of spectrum to be set aside for new entrants as discussed further in Part VI of this Consultation Paper.

In setting the proposed spectrum caps, IDA considered the need to allow operators to bid for as much spectrum as they would require based on their respective business cases, balanced with the need to ensure that the outcome of the auction does not result in a situation that might reduce competition in the mobile market. That being the case, IDA has proposed spectrum caps to ensure that at least three operators will be able to obtain at least 2x20 MHz of FDD spectrum, which IDA believes is the amount necessary to provide nationwide 4G systems and services in Singapore. Setting the spectrum cap at 2x45 MHz (out of the total 2x110MHz on offer) will hence achieve this outcome, while ensuring that operators have an incentive to bid competitively for additional spectrum holdings.

Given the safeguard caps proposed for the FDD category of spectrum, IDA is of the view that no further caps are required for TDD category. Furthermore, given the smaller quantity of TDD spectrum on offer, a spectrum cap may be impractical. However, IDA recognises that this could mean that all the TDD spectrum made available in the auction could be acquired by a single operator.

Question 8

IDA would like to seek the industry's views on the proposed auction parameters for the 4G spectrum rights.

PART VI: NEW ENTRANTS IN THE WIRELESS BROADBAND SERVICES MARKET

50 Given the general industry interest in 4G services, as well as the general growth of consumption of mobile services, IDA is of the view that a new entrant in the mobile market would serve to increase competition in the provision of 4G services, thereby benefitting consumers in reduced prices and non-price innovations. IDA will consider any operator that does not currently provide nationwide mobile system and service coverage in Singapore to be a new entrant.

51 While industry interest is unclear at this juncture, IDA is prepared to customise the proposed framework for the allocation of 4G spectrum to cater for a possible new entrant. Although Singapore is a small market, IDA is aware of significant increases in market demand for mobile data services as well as other innovative services provided over the mobile networks (e.g., mobile payments, location-based services etc). Hence, the possibility of new business opportunities could attract new entrants who may be interested to provide 4G services in Singapore.

52 IDA proposes the following customised framework for a new entrant:

- a. IDA may consider setting aside 2x20 MHz in the 2.5 GHz band (out of the 2x60MHz currently being proposed for allocation), for which only new entrants will be eligible to bid for in the impending reallocation exercise;
- b. While IDA will similarly require the new entrant to provide 4G systems and services with nationwide coverage, IDA is prepared to provide the new entrant with additional time for its deployment. Specifically, IDA will require the new entrant to provide:
 - i. nationwide 4G systems and service coverage (*excluding* MRT underground stations/lines and road tunnels) by 30 June 2018 (i.e., 36 months after the re-allocation of 4G spectrum rights in the 2.5 GHz band); and
 - ii. nationwide 4G systems and service coverage in MRT underground stations/lines and road tunnels by 30 June 2020 (i.e., 60 months after the re-allocation of 4G spectrum rights in the 2.5 GHz band); and
- c. While IDA is of the view that the reserve price for the spectrum set aside for new entrants should be similar to the other spectrum lots priced in the auction, IDA is prepared to consider the case for setting a different reserve price for the spectrum set aside for a new entrant. Further discussions on the reserve price can be found in Part VII of this paper.

53 For the avoidance of doubt, new entrants participating in the bidding for the 2x20 MHz set aside in the 2.5 GHz band are not precluded from bidding for the rest of the 4G spectrum rights on offer in the 1800 MHz, 2.3 GHz and 2.5 GHz bands.

Question 9

IDA would like to solicit interest from potential new entrants in the market. In addition, IDA seeks views on the proposed spectrum set-aside and nationwide 4G systems and service coverage obligations for the new entrant.

Interested parties may submit their comments on the “new entrant” rules in a confidential annex if required.

IDA would also like to seek the industry’s views on whether the reserve price for the spectrum set aside for a new entrant should differ from the spectrum to be auctioned to non-new entrants.

PART VII: PROPOSED PRICING

54 IDA will determine the reserve price for each spectrum lot closer to the date of the auction. IDA notes that besides a well structured auction, reserve price levels are also a mechanism employed in spectrum auctions to manage the risk of bidders engaging in strategic behaviour in order to acquire spectrum at artificially low prices. Such conduct may reduce the efficiency of the spectrum auction process and result in sub-optimal spectrum allocations per bidder. IDA is thus likely to set the reserve price at a level that will reduce the risk of strategic bidding, yet allow interested bidders to participate in the allocation exercise.

55 To arrive at the reserve price, IDA will consider estimates of the market value of the relevant spectrum bands, which include international benchmarks reflective of the value of these bands.

56 For example, IDA has observed the following valuations in spectrum auctions recently concluded in the region: (a) In February 2012, Hong Kong successfully auctioned a total of 90 MHz of spectrum in the 2.3 GHz band for a total sum of HK\$470 million (approximately S\$75 million). In January 2009, Hong Kong successfully auctioned a total of 90 MHz of spectrum in the 2.5 GHz band for a total of HK\$1.5 billion (approximately S\$240 million); and (b) in August 2011, Korea successfully auctioned 20 MHz of spectrum in the 1800 MHz band for a total sum of KRW995 billion (approximately S\$1.1 billion). IDA also notes that the market clearing prices for auctions in parts of Europe in the past year have ranged from approximately S\$0.02 to S\$1.28 per MHz per population. Such auctions include: (a) in February 2012, Switzerland successfully auctioned a total of 575 MHz of spectrum in the 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz and 2.5 GHz bands for a total of CHF 996 million (approximately S\$1.4 billion); and (b) in September 2011, France successfully auctioned a total of 140 MHz of spectrum in the 2.5 GHz band for a total sum of EUR936 million (approximately S\$1.5 billion)¹⁰.

57 IDA intends to set the reserve price for the 4G spectrum at an appropriate level, considering the estimated value of the 4G spectrum, the level of competition in previous auctions for spectrum in Singapore (hence the likelihood of competitive bidding in the auction), among others.

58 Apart from the price paid for the 4G spectrum, winning bidders will also have to pay an annual spectrum fee of S\$14,700 per 10 MHz spectrum lot and S\$26,400 per 2x5 MHz spectrum lot (prices exclude GST). Each successful bidder will also have to pay an Application and Processing fee of S\$2,700 per 10 MHz spectrum lot and S\$5,400 per 2x5 MHz spectrum lot (prices exclude GST).

59 In addition to the upfront auction fee and the spectrum management fees, successful bidders of the 4G spectrum rights will also be required to obtain a Facilities-Based Operator (“**FBO**”) licence from IDA for the deployment of the associated systems and services, if the bidder is not an existing FBO licensee.

¹⁰ The foreign currencies used are converted to S\$ using the latest currency conversion rates.

Bidders should note that under IDA's FBO licence, FBO licence fees are payable according to the FBO licence framework¹¹.

60 In addition, successful bidders which are granted a 4G spectrum right will be required to (where relevant) apply for, and obtain, the relevant Station/Network (Spectrum) Licence(s) before operating the radio-communication systems to provide 4G services using the 4G spectrum lots. The fees payable on such Station/Network (Spectrum) Licences are prescribed in Part I of the First Schedule of the Telecommunications (Radio-communication) Regulations.

¹¹ By the time of the 4G re-allocation exercise, IDA's revised licence fees for FBO licensees will have come into effect. More information on IDA's revised licence fees can be found at the following weblink: <http://www.ida.gov.sg/News%20and%20Events/20111124114423.aspx?getPagetype=20>.

PART VIII: CROSS BORDER CO-ORDINATION

61 As discussed in paragraphs 26 to 31, the implementation of full band sharing in the 2.5 GHz will require the telecom operators to co-ordinate the use of the spectrum and also, take effective measures to prevent their radiocommunications facilities from causing interference to other legitimate telecommunication facilities installed in and close to the border areas.

62 IDA is of the view that the ECC/REC/(11)05 Recommendation provides adequate parameters for operators to conduct cross border coordination for the Mobile/Fixed Communication Networks in the 2.5 GHz frequency band. IDA will in turn work with the neighbouring countries to ensure that the same Recommendation is adopted for cross border coordination.

Question 10

IDA invites views and comments on the adoption of the ECC/REC/(11)05 Recommendation for cross border coordination in the 2.5 GHz band in Singapore.

63 In IDA's earlier public consultation, IDA shared that the 2520 MHz to 2670 MHz band has been allocated for the use Broadcast Satellite Services ("**BSS**") in Indonesia. To ensure the harmonious co-existence of the different services deployment with our neighbouring countries, it is important to set the technical parameters for the deployment of the 4G mobile communication systems in the 2.5 GHz band.

64 Some possible deployment parameters were shared in the IDA's earlier public consultation which includes the limiting of the emission power and the down-tilting of the base stations' antennas located at the border areas. With this, IDA is of the view that by limiting the emission power to 20W and down-tilting the base stations' antennas by 6°, it will be sufficient for the 4G systems in Singapore to co-exist with the BSS systems in Indonesia. Notwithstanding the establishment of the 4G systems' deployment parameters, operational co-ordination between the BSS and telecom operators will be required should interference occur.

Question 11

IDA invites views and comments on the practical measures for the deployment of 4G base stations at the border areas for the harmonised co-existence with the BSS in Indonesia.

65 IDA notes that Ofcom has conducted trials with the UK Civil Aviation Authority on the co-existence of the 4G systems in the 2.5 GHz band and the radar systems that operate in the adjacent frequency band of 2700 MHz to 2900 MHz. Although there is a 10 MHz guard band (2690 MHz to 2700 MHz) between the adjacent services, the trial results showed that interference between the two systems is possible.

66 IDA is of the view that the ECC Report 174 provides adequate mitigation parameters for mobile services to co-exist with radar systems. Considering the parameters provided in the ECC Report 174 and other available studies, IDA proposes to introduce the regulatory limit of -65dBc for the unwanted emission of the

base stations and mobile service terminals, in order to reduce the potential interference to the radar systems.

Question 12

IDA invites views and comments on the possible practical measures that the operators would implement to allow coexistence of mobile services and radar services in the adjacent band.

IDA also invites views and comments on the required mitigation parameters indicated in the ECC Report 174 and the regulatory limit proposed by IDA for the co-existence between mobile services in 2.5 GHz with S-band radars.

PART IX: USE OF 900 MHZ AND 1800 MHZ SPECTRUM BANDS FOR SECOND GENERATION (“2G”) SYSTEMS AND SERVICES

67 As mentioned above, since 2008, IDA has allowed the mobile operators to deploy 3G services in the PCMTS bands to meet their demand for mobile data capacity.

68 Based on IDA’s statistics, as at December 2011, there were 2.00 million 2G subscriptions in Singapore. This represents a drop of 23% from 2.58 million subscribers in December 2010 and a drop of 46% from the 3.70 million 2G subscribers in December 2009. In contrast, from December 2009 to December 2011, 3G subscriptions rose from 3.16 million to 5.76 million, a rise of 82%. Furthermore, the relatively slower mobile data speeds offered by 2G may no longer meet the needs of today’s and tomorrow’s mobile data subscribers.

69 Given the market trends¹², there are signs that 2G may become increasingly displaced by 3G and, potentially 4G going forward. This is particularly in the Asia Pacific¹³, as a result of the rising trend of mobile operators deploying 3G and LTE services using existing 2G spectrum. Nonetheless, it is not envisioned that mobile operators will shut down their 2G network totally in the near term, especially in Europe and South East Asia, where the GSM networks are used as the backbone of voice communication and roaming.

70 Notwithstanding the declining subscriber base, IDA is aware that there is still demand for 2G services from pre-paid mobile subscribers. As at December 2011, there were still 1.80 million pre-paid 2G subscribers. IDA understands that such pre-paid 2G subscribers are largely transient workers and low-income families which may prefer pre-paid to post-paid mobile subscriptions. We also note that GPRS services riding on 2G networks are commonly used for Machine-to-Machine communications today, e.g., alarm systems. There may also be possible demand from inbound roamers for 2G services.

71 However, in the longer term as with all technology progress, it may be inevitable that the dwindling 2G subscriber base coupled with increasing demand for 3G and 4G services will result in operators switching to providing 3G or 4G services completely, and shutting down the legacy 2G network.

72 IDA would therefore like to seek the views of the 2G service providers and the industry at large on whether any measures should be adopted to facilitate the efficient use of 2G spectrum during the phase out of 2G, among others.

Question 13

IDA would like to seek the industry’s views on whether IDA should: (1) allow the 2G service providers to individually decide on when to shut down their 2G networks; or (2) intervene or assist to facilitate in any aspect of a possible winding down of 2G

¹² According to PCWorld, 2G technology will be phased out completely between 2010 to 2015 to make way for the growing 3G and LTE networks.

¹³ The Korean cellular operator KT Corp has obtained the Korean Communications Commission’s approval to shut down its GSM services in Korea and deploy 4G network using the 2G spectrum by 2012. In Japan, cellular operator NTT DoCoMo announced the shutdown of its 2G network in 2011. Australian cellular operator Telstra announced the shutdown of its GSM network by 2012.

services in Singapore in order to manage the efficient use of spectrum. Such intervention could include the possibility of IDA centrally managing the 2G spectrum made available, e.g., by specifying spectrum, to be used by the 2G service providers on a shared basis for a shared 2G network.

PART X: INVITATION TO COMMENT

73 IDA would like to seek the views and comments from the industry and members of the public on its proposed framework for the reallocation of spectrum for 4G telecommunication systems and services.

74 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, 8 May 2012**. 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:

**Ms Aileen Chia
Deputy Director General (Telecoms and Post)
Infocomm Development Authority of Singapore
10 Pasir Panjang Road
#10-01 Mapletree Business City
Singapore 117438
Fax: (65) 6211 2116**

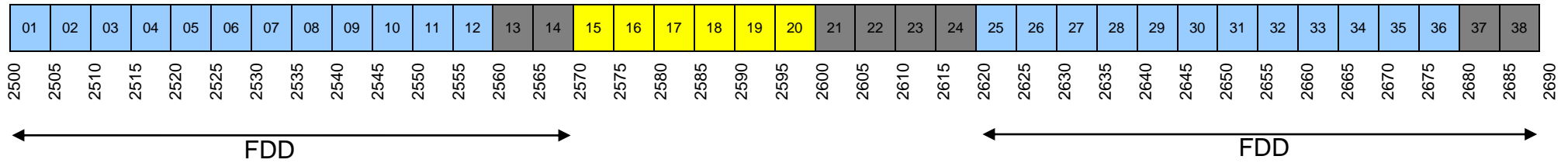
AND

Please submit your soft copies, with the email header "Consultation on framework for the reallocation of spectrum for 4G telecommunication systems and services" via email to IDA_consultation@ida.gov.sg.

75 IDA reserves the right to make public all or parts of any written submissions made in response to this consultation, and to disclose the identity of the respondent. Any part of the submission which the respondent considers is commercially sensitive must be clearly marked and placed as a separate annex to the comments raised. IDA will take this into consideration when disclosing the information submitted.

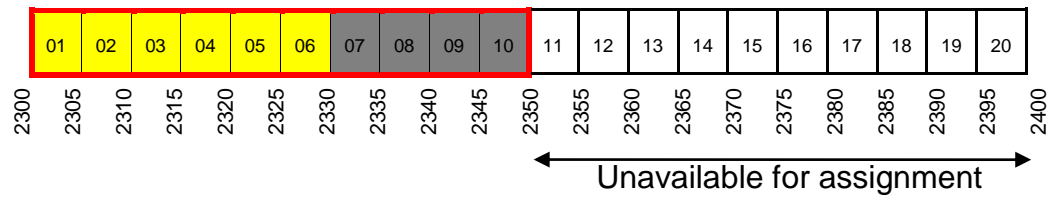
POSSIBLE ALLOCATION OF SPECTRUM IN THE 2.3 AND 2.5 GHz BANDS IN 2015 AND THE 1800 MHz BAND IN 2017

2.5 GHz



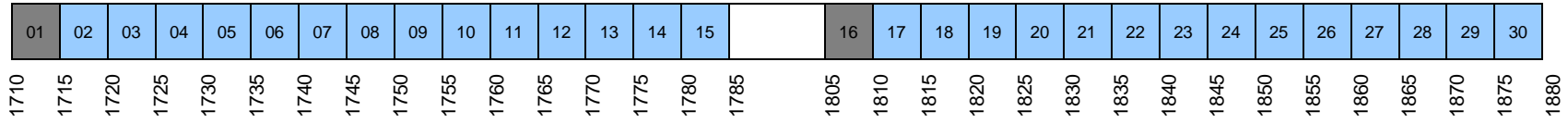
Reserved spectrum – 2x10 MHz paired for FDD and 20 MHz for TDD band


2.3 GHz



Reserved spectrum – 20 MHz

1800 MHz



 Reserved spectrum – 2x5 MHz paired

DESCRIPTION OF COMMONLY USED SPECTRUM AUCTION FORMATS

1) Simultaneous Multiple Round Auctions (SMRA) and variants

The SMRA format has been used for spectrum auctions worldwide on many occasions since it was introduced by the Federal Communications Commission (“**FCC**”) in 1994 for its auction of 10 paging licenses. The FCC alone has conducted in excess of 70 spectrum auctions using the SMRA format. IDA also adopted the SMRA format during its Wireless Broadband Spectrum Rights Auction in May 2005.

How it Works:

- Each spectrum lot has its own individual price in each round (“the going price”). In the first round the going price of each spectrum lot is the reserve price.
- Bidders bid for specific spectrum lots. After each round, a standing high bidder is identified for each spectrum lot (unless a spectrum lot has received no bids, in which case it remains unsold). When more than one bidder has placed a bid at the going price on a spectrum lot, the standing high bid is chosen at random.
- A bidder who has the standing high bid on a spectrum lot cannot change his bid until a new and higher bid has been placed on the spectrum lot by another bidder.
- A bidder who has a bid on a spectrum lot that is not the standing high bid has the following options:
 - the bid can remain unchanged (in which case eligibility is reduced, as explained below);
 - the bid can be increased; or
 - the bid can be switched to another spectrum lot.
- Bidding is subject to activity and eligibility requirements. In order to maintain eligibility, a bidder has to be active. A bidder is active when a new bid is placed, either as an increased bid on the same spectrum lot, or as a switched bid on a different spectrum lot. A bidder is also active when a bid is the standing high bid. A bidder who is not active will lose eligibility to place bids. When all eligibility is lost, the bidder has effectively withdrawn from the auction.
- The auction closes in the round when no new bids are placed. Winning bids are the standing high bids when the auction closes.

SMRA with generic lots

- The SMRA format can be adapted so that bidders bid on generic lots. This addresses the problem of bidders winning non-contiguous spectrum. The key difference from the standard SMRA is that:

- Bidders first bid on a generic set of spectrum lots rather than specific lots; and
- At the end of the bidding, there is an assignment stage to allocate the lots that are won within the spectrum band. The assignment stage can be a simple sealed bid auction where bidders are asked to place bids on different placement options, under the constraint that only contiguous blocks are presented as bid options.

SMRA with switching

- The key difference is that standing high bids can be switched to different spectrum blocks. This flexibility in the switching rule reduces the risk of an auction outcome where one or more bidders will be awarded non-contiguous spectrum lots.

Clock auction

- The clock auction is a variation on the SMRA format, in which bidders specify demand for quantities of lots within categories instead of individual lots. In each round, there is a single common price for all lots within a category, and this price ‘ticks’ up over successive rounds until there is no longer any excess demand. The basic clock auction format was designed for a single category of lots (e.g. one frequency band with many identical lots).

2) Combinatorial Clock Auction (CCA)

The CCA format was developed in the UK as a practical package bid alternative to the traditional SMRA format. It has subsequently been adopted by at least six other countries. The CCA format is attractive because it has the potential to deliver more efficient outcomes than an SMRA in situations where bidders are seeking multiple spectrum lots, bidders have different demand structures, and there are strong synergies between lots. This is because the package bid approach eliminates aggregation risk (i.e., risk of winning only part of a set of spectrum that only has value when the full set is won), while encouraging straightforward bidding and significantly curtailing incentives for gaming strategies. This format has been used recently in UK, Switzerland, Netherlands and Denmark.

How it Works:

The CCA is a package bid auction format that is usually implemented with generic lots (to simplify bidding) and a second price rule (to encourage straightforward value-based bidding). In its typical deployment, the CCA consists of the following stages:

- The CCA is usually prefaced by an *Application Stage*, in which each bidder is invited to apply for its preferred package of spectrum across all categories at the reserve prices. The application bids are added up by the auctioneer, and if there is excess demand in any category the auction proceeds to the *Principal Stage*. In this case, the initial application determines the bidder’s initial eligibility in the first primary round. Otherwise, bidders win their application bids, and the award proceeds directly to the *Assignment Stage*.

- The *Principal Stage* consists of a number of primary rounds and a single supplementary round, followed by winner and price determination:
 - In each primary round, each bidder bids for a single package of lots at prevailing prices. Prices for categories in excess demand are increased for the next round, and the bidding process continues until there is a round in which there is no excess demand in any category.
 - A supplementary round always follows the primary rounds. This is a single round sealed bid in which bidders may submit bids on multiple packages subject to constraints imposed by their primary round bid decisions. This round is required because the primary rounds may not achieve an outcome in which all spectrum is allocated most efficiently.
 - At the end of the *Principal Stage*, winning bids and base prices are determined drawing on all bids submitted throughout the process, i.e., both primary round bids and supplementary round bids are taken into account.
- If lots were sold on a generic basis, an *Assignment Stage* is required to assign specific frequencies to the winning bidders within each category. Typically, a series of sealed bids for each category are run, with bid options constrained to ensure winning bidders receive contiguous assignments.

PROPOSED CLOCK PLUS AUCTION FORMAT

With a single category of lots, a Clock Plus auction would be implemented as follows:

- There is a single “clock”, which specifies the price per lot of spectrum within the category. The price indicated on the clock will start at the reserve price and ticks upward in each round, unless and until there is a round with no excess demand.
- At the start of the auction, the amount of lots each bidder can bid for is determined by the spectrum caps in place.
- In each round, bidders submit a “clock bid” for a quantity of lots at the round price. This is a package bid which cannot be broken up. The size of this bid determines the bidders’ eligibility in the next round. Thus, in each successive round, as prices increase, a bidder may only bid for the same or smaller package than in the previous round (or exit the auction).
- If a bidder drops eligibility for any lot, it has the option to submit an “exit bid” for each quantity of lots that it can no longer bid for in later rounds. Exit prices for a package must be:
 - Less than the current round price for that package;
 - Greater than any previous bids for the package;
 - Not less than any bids for smaller packages; and
 - Not less than the reserve price for the package.
- All clock bids and exit bids remain valid throughout the auction and could be selected as winning bids according to the rules described below.
- The auction ends when there is a round in which aggregate demand (the sum of demand across all package bids submitted at current prices) is equal to or less than supply.
- Winning bidders are determined as follows:
 - If demand in the final clock round exactly matches supply, then all final round clock bids are winning bids, and all other bids are rejected.
 - If demand in the final clock round is less than supply, then:
 - Bidders who submitted a final round clock bid are guaranteed to win at least the quantity of lots specified in their bid.
 - To allocate the remaining lots, IDA will identify the highest value combination of clock bids and exit bids than may be accommodated,

considering both incremental demand from bidders who are already winners and full demand from other participants.

- All winning bidders pay the prices associated with their winning bids.

In a Clock Plus auction with multiple categories, there would be multiple price clocks, one for each category. Each clock would only tick upwards if there was excess demand in that category. The auction closes when there is a round in which all clocks stop moving.