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

PROPOSED REGULATORY FRAMEWORK FOR TV WHITE SPACE OPERATIONS IN THE VHF/UHF BANDS

17 June 2013

PART I: INTRODUCTION

1. Spectrum is finite and with the increase use of wireless devices, there is a greater need for more efficient and optimised use of this resource. TV White Space ("**TVWS**") technology is one such innovation that allows opportunistic access to underutilised spectrum in the TV Very High Frequency ("**VHF**") and Ultra High Frequency ("**UHF**") bands to deliver wireless services. This untapped source of spectrum, known as "white spaces", is well placed to increase the capacity of mobile bandwidth and provide high-speed wireless connectivity to provide wireless broadband Internet access services, machine-to-machine connectivity, smart metering and outdoor environment or security monitoring networks.

2. In order to exploit and harness this underutilised spectrum, IDA is considering the use of this spectrum band for the deployment of cognitive radio devices, also commonly referred to as White Space Devices ("**WSDs**").

3. Since 2009, IDA has conducted several trials to study the benefits of TVWS technology and concluded that enabling WSD access to the white spaces can potentially increase the availability of broadband services in Singapore and improve overall spectrum efficiency. However, it is important for IDA to define the licensing mechanism and guidelines for operation of WSDs in Singapore in order to provide regulatory certainty and facilitate their deployment, and at the same time protect incumbent services operating in these bands.

4. The objective of this consultation is to seek views from the industry on the proposed regulatory framework for the operation of TVWS in the UHF and VHF bands. The regulatory framework tailored for Singapore's white space environment will be developed based on international best practices, and contextualised to Singapore's geographical conditions and market environment based on TVWS trial results and responses to this consultation. The overall regulatory framework will be designed to ensure coexistence between WSDs and the existing incumbent users of the TV VHF/UHF band, which are broadcasting services, wireless microphones and Private Mobile Radio ("**PMR**").

5. IDA recognises that the detailed technical specifications of the wireless communication protocols amongst WSDs, and the standards for the communication protocols between WSDs and databases, is a matter for the industry to develop. Hence, the focus of this consultation is to seek views on the proposed regulatory approach to facilitate coexistence between WSDs and incumbent services, which include factors such as the operational parameters for WSDs, protection criteria and the development of a geolocation database.

PART II: LICENSING MECHANISM FOR WHITE SPACE DEVICES

6. The US Federal Communications Commission ("**FCC**") is allowing WSD operations on a licence-exempt basis, with the management of such devices through a database. The Office of Communications ("**OFCOM**") in the UK is adopting a similar approach. IDA is also considering adopting the same approach to facilitate the initial deployment of WSD in Singapore. Such an approach will allow users to test a range of business models and enable innovative services to flourish. In Singapore, wireless devices that are currently operating on a licence-exempt basis include Wireless Local Area Network (e.g., WiFi) and Bluetooth devices.

7. Under IDA's regulatory framework for radiocommunication deployment, the operation of licence-exempt devices will be subject to conditions set by IDA, for example power transmission limits[1]. IDA proposes to adopt a licence-exempt framework for the operation of WSDs, subject to conditions set forth by IDA.

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

8. Through our engagement with the industry, it was highlighted that although adopting a licence-exempt approach for WSDs would lower costs for users, one concern is the lack of guaranteed spectrum availability. This might be a barrier for the industry to deploy services that require certainty of spectrum access.

9. Taking this into consideration, IDA is exploring the benefits of designating some channels within the TVWS spectrum to support the deployment of such services. However, this approach would require further study by IDA as there are several factors that need to be taken into account. Firstly, consultation with the industry is necessary to gauge the level of interest in deploying 'real-time' services over TVWS and to identify suitable channels for such deployments. Secondly, IDA would need to consider the appropriate regulatory approach in designating specific TVWS channels that will allow operation of prioritised WSDs[2] over other WSDs, as well as the regulatory framework governing the deployment of such prioritised WSDs if the proposed licence-exempt mechanism is not appropriate.

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

[1] The conditions for licence-exemption are defined in the Telecommunications (Exemption from sections 33, 34(1)(b) and 35) Notification. Although the deployment of WSDs in the TVWS spectrum will be licence-exempt, the provision of telecommunication service using WSDs will be still subject to licensing.
[2] Prioritised WSDs are likely to require certainty of spectrum access to deploy 'real-time' services.

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

PART III: TV WHITE SPACE SPECTRUM BANDS AND ACCESS MECHANISM

TV White Space Spectrum Bands

10. IDA has allocated the VHF spectrum between 174 MHz and 230 MHz, and the UHF spectrum between 494 MHz and 790 MHz for the provision of broadcast services on a primary basis (shall be referred to as "**primary**" user or service in this Consultation Paper). In addition, Private Mobile Radios ("**PMR**"), along with both licensed and licence-exempt wireless microphones also operate in these bands (PMR and licensed wireless microphones shall be referred to as "**secondary**" user or service in this Consultation Paper). However, these three services do not fully utilise all VHF and UHF channels at all times, and in all locations. The channels that are unused by primary and/or secondary users, often on a geographic-limited and time-limited basis, can possibly be made available for use by other services.

11. TVWS technology is designed to operate in parts of the TV spectrum bands that are not used by primary and/or secondary services. In the earlier white space trials, Cognitive Radio Venues ("**CRAVE**")[3], that were carried out by IDA in Singapore, only a limited number of these spectrum channels were made available for the CRAVE trials. However, most VHF and UHF channels could be considered as potential white spaces as long as the protection to primary and secondary services can be ensured.

12. In summary, excluding the channels that are currently assigned to primary services, the channels summarised in Table 1 are potentially available for WSD deployment in Singapore. The 694 MHz to 806MHz band has been earmarked for International Mobile Telecommunications ("**IMT**") services in Singapore, but in the interim it is possible to optimise this band for WSD operations until Analogue TV Switch Off [4] ("**ASO**") currently planned to be by 2020. Upon ASO, there will be changes to the list of available TVWS channels.

Table 1 Candidate TVWS channels

	TVWS Channels	**Total No. of Channels**	**Total Bandwidth**
VHF Band	i) 181 - 188MHz (Channel 6) ii) 209 - 223MHz (Channel 10 and 11)	3	21MHz

[3] CRAVE was designed as a proof-of-concept trial to validate that WSDs could be deployed without causing any impact or interference on existing broadcast services. The CRAVE trial framework can be found on this website: http://www.ida.gov.sg/Policies-and-Regulations/Industry-and-Licensees/Spectrum-Management/Spectrum-Planning/White-Space-Initiative-Through-Spectrum-WITS

[4] As IDA is proposing to adopt the geolocation database approach as the primary means for WSD to access white space spectrum (see Para 14 of this Consultation Paper), transitioning the WSD out of the IMT band (694 – 806MHz) is expected to be a relatively simple process of blocking these channels from WSD usage in the database. For more information, please refer to http://www.mda.gov.sg/International/Pages/ASEAN.aspx.

	TVWS Channels	**Total No. of Channels**	**Total Bandwidth**
UHF Band	i) 502 - 518MHz (Channel 25 and 26) ii) 614 - 622MHz (Channel 39) iii) 630 – 710MHz (Channel 41 to 50) iv) 718 – 742MHz (Channel 52 to 54) v) 750 – 774MHz (Channel 56 to 58) vi) 790 - 806MHz (Channel 61 and 62)	21	168MHz

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

Mechanism to Access TVWS

13. Currently, spectrum sensing and geolocation database ("**database**") are the only two mechanisms to access white space spectrum. However, as spectrum sensing technology is still at a nascent stage of development, there is global consensus on the use of the database method to manage access to white space spectrum. The respective TVWS policies developed by the FCC and OFCOM require the operations of WSDs to be managed through the use of a database.

14. Hence, it is recommended that Singapore adopts a database approach as the mandated method for WSD to access white space spectrum. WSDs[5] will be required to access an authorised database, via an Internet connection, in order to acquire information on spectrum availability and transmission power level at the relevant operating location. This approach will protect primary and/or secondary services by preventing WSDs from operating on channels where they could cause interference to these services, or by limiting their power transmissions so that they can coexist with primary and/or secondary services.

15. Notwithstanding the use of the database method, IDA does not rule out the possibility of using spectrum sensing as a means for WSDs to access white space spectrum in the future. IDA recognises the benefits for industry to continue investing in research and innovation efforts in developing spectrum sensing technology, and will continue to study the feasibility of using spectrum sensing as a viable alternative method as the technology develops.

Question 5:
IDA invites views on adopting a database approach as the mandated method to access white space spectrum.

[5] Depending on the type of WSD and its mode of operation (see Paragraph 19)

16. Process-wise, IDA envisages that WSDs querying the database will receive a list of available white space channels which the WSDs can operate in, and the corresponding maximum transmission power limits. IDA will also require all WSDs that operate at a higher power level (above 100mW) to register its location and contact information within the database. In the event of interference caused by a WSD to a primary and/or a secondary service, this registration measure will assist IDA in identifying the interfering WSD and the person/company involved.

17. In the event where a WSD is unable to establish contact with an authorised database or when the authorised database becomes unavailable, the WSD must cease transmission. To minimise the risk of interference, it is proposed that WSDs will query the database and request up-to-date information in the following situations:

a) when the WSD has just powered up;
b) when the WSD has moved considerably, in this case ≥50 meters (m) from its original location; and
c) when the time validity of the WSD's operating channel has lapsed.

18. Requiring WSDs to be updated on the time validity ensures that WSDs re-query the database at regular intervals, to keep up with the dynamic nature of spectrum usage within the white space spectrum. The length of the time validity will be determined by the frequency in which IDA updates its database of primary and secondary users. The rationale and considerations taken by IDA in determining the time validity is elaborated in Part VI of this document.

Question 6:
IDA invites views on the proposed general requirements for the database query and registration.

Question 7:
IDA invites views on the three situations in which a WSD must query the database. In particular, IDA invites views on defining 50m as the maximum distance that WSDs are allowed to move from its original location, without contacting the geolocation database.

PART IV: COEXISTENCE CRITERIA AND OTHER PARAMETERS FOR WHITE SPACE DEVICES

Technical and Operational Parameters of WSD

19. Similar with the approach adopted in the US by the FCC, it is recommended that three types of WSDs be allowed in Singapore:

a) Fixed Device: Fixed Devices should have the ability to query the database and select a TVWS channel for operation based on the list of available TVWS channels provided by the database. A Fixed Device shall have the ability to transmit at a power level capped at a maximum of 4W EIRP. Fixed Devices are able to initiate a network by sending enabling signals to other client devices. IDA will require all TVWS networks to have at least one Fixed Device or Mode II Device (see below) at all times.

b) Mode I Device (Portable): Operation by the Mode I Device will only be allowed with the presence of a Fixed Device or Mode II Device in the same TVWS network. Due to its mobility, IDA will require the transmission power of such devices to be capped at a maximum of 100mW EIRP. This mode of operation does not require the use of geolocation capabilities and will not require access to the database, but will determine its operating channel through a Fixed or Mode II Device.

c) Mode II Device (Portable): Mode II Devices will be required to have an in-build geolocation capability and the ability to query the database to select a TVWS channel for operation based on the list of available TVWS channels provided by the database. Due to its mobility, IDA will require the transmission power of such devices to be capped at a maximum of 100mW EIRP. IDA will require all TVWS networks to have at least one Fixed Device or Mode II Device at all times.

20. IDA intends to align the transmission output power of WSDs in Singapore with commercially-ready products, which is to allow a maximum of 4Watts EIRP for Fixed Devices and 100mWatts EIRP for Mode I and II Devices. The transmission output power[6] is characterised as the total transmit power in the entire emission bandwidth (i.e. 7MHz for VHF channels and 8MHz for UHF channels) measured at the antennas.

21. For Fixed Devices, IDA is considering allowing a tuneable transmission power that is capped at 4Watts EIRP to provide flexibility and increased access to white space spectrum. The transmission power of the WSD will be determined by the database and it will be dependent on the protection criteria defined by IDA, the antenna height and location of the WSD. The overall characteristics and mode of operations are summarised in Table 2.

[6] Power must be aggregated across all antennas and antenna elements and if multiple modes of operation are possible (*e.g.*, alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

Table 2: General Parameters of the WSDs

	Fixed Device	**Mode I Device (Portable)**	**Mode II Device (Portable)**
Ability to Query the Database	Yes	No	Yes
In-build Geolocation Capability	Optional	No	Yes
Maximum Power Level	4Watts EIRP	100mW EIRP	100mW EIRP
Tuneable Power Level	Optional	Optional	Optional

Question 8:
IDA invites views on the output power transmission of WSDs as shown in Table 2.

Question 9:
IDA invites views on allowing the Fixed Devices to have tuneable output power that is capped at a maximum of 4Watts EIRP.

Unique WSD Identifier

22. The purpose of a unique WSD Identifier is to enable the database to uniquely identify a WSD. FCC has implemented such an identification mechanism through the FCC Identifier and manufacturer serial number in their TVWS regulations. IDA is of the view that such an identifier is necessary but this should ideally be internationally harmonised. This issue is currently being addressed in the European harmonised standard under development by the European Telecommunications Standards Institute ("ETSI") for Broadband Radio Access Networks.

Question 10:
IDA invites views on the requirement of a Unique WSD Identifier and for this identifier to be based on standards developed by recognised standards organisations.

Coexistence of WSD with Local Broadcasting (Primary) Services

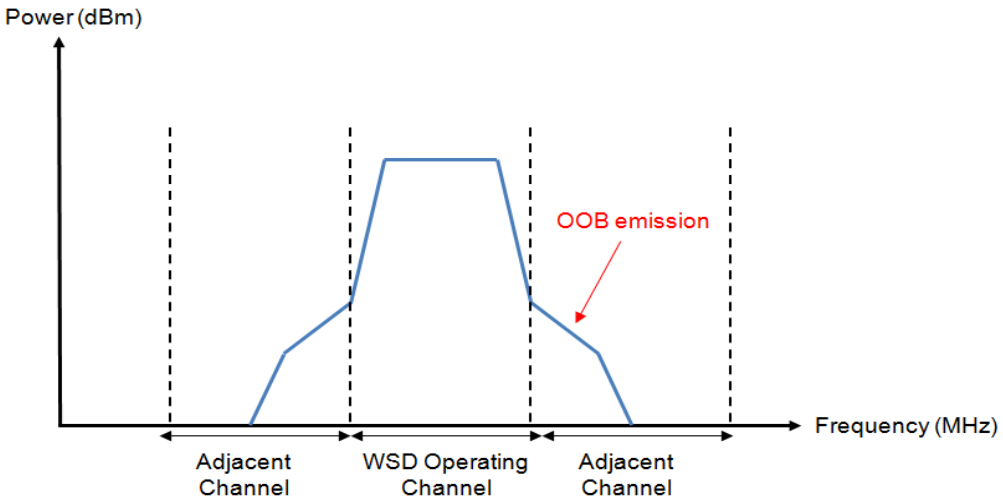
23. Currently, there are two approaches developed by FCC and OFCOM to avoid interference with local broadcasting services and to determine spectrum availability using the database. These approaches are developed with an emphasis on protecting local broadcasting services. In Singapore's context as local broadcast spectrum cannot be reused in a small geographic area like Singapore, the channels used to provide broadcasting services in Singapore will not be made available for WSDs operations.

24. As such, the coexistence parameters for WSD deployments should focus on adjacent channel operations between a WSD and local broadcast service. It is proposed that only Mode I and II Devices operate in the adjacent channels because these are low powered devices that are unlikely to cause interference to broadcast services, and this means that the power transmission limits in the adjacent channels will be capped at 100mWatts EIRP.

Question 11:
IDA invites views on the proposed maximum transmission level of 100mW EIRP for WSDs operating in channels adjacent to a local broadcast channel.

25. Besides limiting the transmission power of WSDs operating in channels adjacent to a local broadcast service, it is also important for IDA to define the appropriate out-of-band ("**OOB**") emission limit. OOB emissions are unwanted spurious emissions that fall outside the normal operating channel[7] of WSDs, which may lead to potential interference to local broadcast services operating in adjacent channels (see Figure 1).

Figure 1: Potential Interference Issue Caused by OOB emissions



26. As such, to ensure the protection of local broadcast services, it will be necessary to define the OOB emission limits for WSDs operating in channels that are adjacent to local broadcast channels. These limits will ensure that the OOB emission level at the adjacent channel will be substantially lower than that of the primary service reception level, which in this case is local broadcast services, to prevent any interference issue.

27. Due to the highly urbanised environment of Singapore, local broadcast receivers are generally installed in most areas of Singapore. Taking this into consideration, it is assessed that stringent OOB emission limits is necessary for WSD operating in channels adjacent to local broadcast services. It is proposed that for such channels, OOB emission from the WSD should not exceed -56.8dBm. As this is in line with the OOB emission limits that were defined by FCC, it is likely that there are commercially available WSDs that meet the proposed OOB emission requirements.

[7] The operating channel for a WSD is 7MHz and 8MHz for a VHF and UHF channel respectively

Question 12:
IDA invites views on the proposed OOB emission limit of -56.8dBm, which will be imposed on WSDs operating in channels that are directly adjacent to a local broadcast service.

28. For WSDs that are not operating adjacent to a local broadcast service, it is possible to relax the OOB emission limits. As highlighted in Table 1 in Part III of this document, there is a significant amount of contiguous TVWS channels in Singapore, where the WSDs will be operating adjacent to each other. IDA is of the view that OOB emission limits may not be necessary for adjacent WSD to WSD operations, since both devices are operating on a licence-exempt basis. This issue can be managed by the industry to determine the best approach to avoid mutual interfere between WSDs, rather than for IDA to limit OOB emission levels in such a situation.

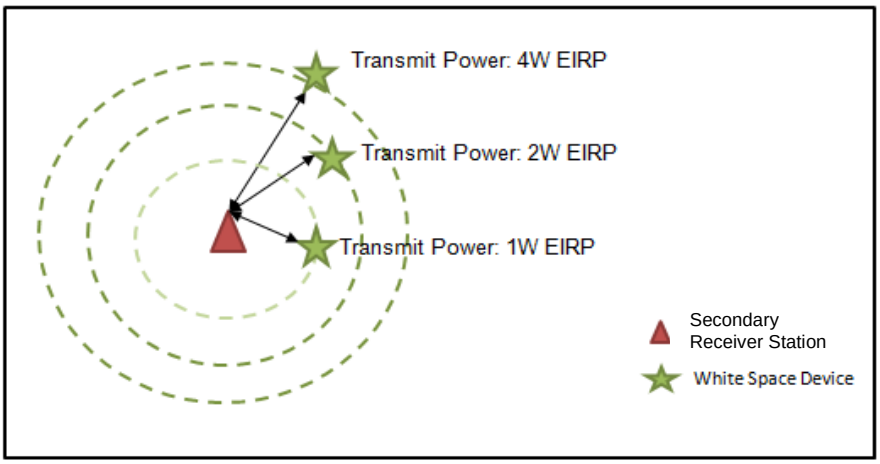
Question 13:
IDA invites views on defining the OOB emission limits for WSD to WSD operations.

Coexistence of WSD with Secondary Services

29. There are secondary users within the TVWS channels, such as the licensed PMR and wireless microphone operations in Singapore. In order to ensure protection of secondary users within the TVWS channels, IDA proposes to implement coexistence criteria to protect existing services from harmful interference. The coexistence criteria defined within this section will be focused on co-channel usage since the WSD and the other secondary services are occupying the same spectrum channel. As such, to ensure coexistence there has to be sufficient spatial and distance separation between a transmitting WSD and a receiving secondary station.

30. It is envisaged that as a WSD is situated further away from a secondary receiver station, it is possible to increase the transmission power level so as not to cause any interference to the secondary device (illustrated in Figure 2). As such, IDA is proposing an approach where the database will return information of spectrum availability and permissible power level to a WSD, based on its location of operation. However, this approach will only be feasible if the transmission power level of a WSD is not fixed and can be tuned within the range of 100mWatts EIRP to 4 Watts EIRP.

Figure 2: Multiple Transmission Power Level Approach



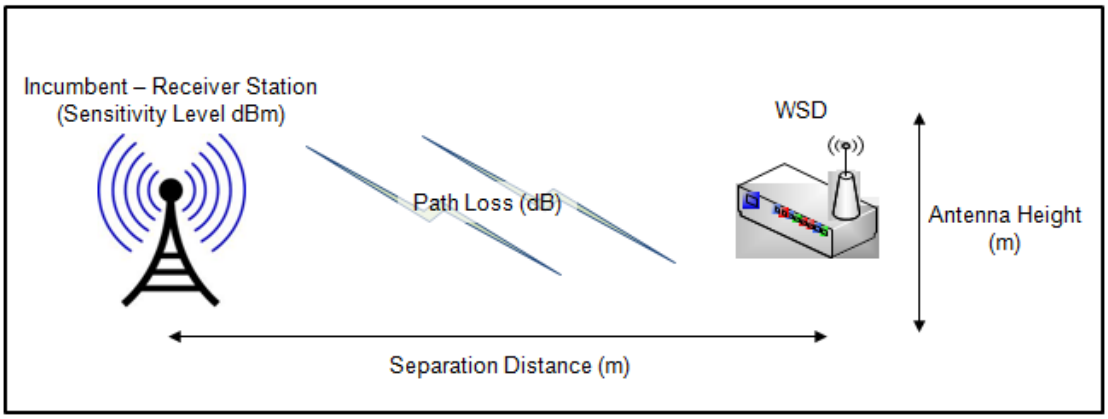
31. In the event where a WSD queries a database, the database will have to determine the separation distance between a WSD and secondary receiver stations. The database shall then return information on the TVWS channels available at its location and the maximum transmission power for each channel.

Question 14:
IDA invites views on the proposed approach to manage coexistence between a WSD and the other secondary services within the TVWS channels.

32. IDA has considered three propagation modelling methodologies for a database to compute the maximum permissible transmission power of a WSD, and the scenario is highlighted in Figure 3:

a) Free Space Path Loss Model ("**FSL**");
b) Hata Okumura Path Loss Model ("**Hata**"); and
c) Longley Rice Path Loss Model

Figure 3: Scenario Used in Computing the Maximum Transmission Power for a WSD



33. The Longley Rice model has been predominantly used for modelling frequency planning in television broadcasting and is generally not used in other types of wireless communications networks. As for the FSL model, although it provides the most stringent figures, this may not accurately reflect the path loss for Singapore, especially with our urbanised environment. IDA is of the view that the Hata model will be more appropriate for Singapore's environment, since this model is well accepted for modelling the signal propagation in urban areas and widely used by commercial or research institutions.

34. Aside from the path loss figure that will be determined by the Hata model, the technical parameters used to compute the WSD's maximum transmission are referenced from ETSI/Electronic Communications Committee Reports and noise floor measurements taken in Singapore. With the highly urbanised environment in Singapore, the noise floor is generally at a higher level. The table below highlights measurements taken at four locations in Singapore, where the average noise floor level in Singapore is between -110dBm to -115dBm.

Table 3: Noise Floor Levels in Singapore

Band Scanned	West Coast Park	East Coast Park	Sembawang Park	Kranji Park
181 – 188 MHz	-110 dBm	-110 dBm	-110 dBm	-100 dBm
209 – 223 MHz	-110 dBm	-110 dBm	-115 dBm	-110 dBm
502 – 510 MHz	-115 dBm	-110 dBm	-115 dBm	-115 dBm
614 – 622 MHz	-115 dBm	-115 dBm	-110 dBm	-115 dBm
630 – 782 MHz	-115 dBm	-100 dBm	-115 dBm	-115 dBm
790 – 806 MHz	-115 dBm	-115 dBm	-115 dBm	-115 dBm

35. Based on IDA's analysis and study, the table highlighted in **Annex A** provides an example for the maximum transmission power of a WSD with varying separation distance from a secondary receiver.

36. Considering the above, IDA assesses that co-channel usage between a secondary user and a WSD is possible with the right propagation model to compute the minimum separation distance and appropriate transmission power. In summary, a WSD may operate in the same TVWS channel with a PMR or licensed wireless microphone user when the separation distance is more than 9km away for 4Watts transmission and 3km for 100mWatts transmission[8].

Question 15:
IDA invites views on the proposed propagation model and parameters used to determine the maximum transmission power level of a WSD.

Management of Licence-Exempt Wireless Microphones

37. For licence-exempt wireless microphones currently operating in the TVWS channels in Singapore, the whereabouts of these devices are not known to IDA as these licence-exempt devices are not registered with IDA. Hence, there is a need to propose an alternative approach in addition to the propagation model and parameters proposed above to manage coexistence between WSDs and secondary services.

38. From a regulatory perspective, both licence-exempt wireless microphones and WSDs should not be offered protection from each other's operations since both are operating on a licence-exempt, unprotected basis. However, it is important to ensure coexistence of both sets of operations to maximise efficient use of the spectrum. IDA notes the approach taken by FCC in managing the coexistence of these two sets of devices, which is to designate safe harbour channels for wireless microphone operations.

39. IDA is of the view that adopting such safe harbour channels may be appropriate for Singapore as well. IDA has assessed that such safe harbour channels could accommodate up to 20 wireless microphones per location. It is proposed that these channels should not be made available to WSDs. As wireless microphone

[8] The separation distances and power transmission levels were determined using the Hata propagation model, with the antenna height of 30m and 1m for the transmitting and receiving antenna respectively.

operates in low power modes, the typical coverage area is limited to 500 to 1000 metres and these safe harbour channels can be reused in multiple locations across Singapore. With the database, IDA has the flexibility to increase or decrease the number of safe harbour channels depending on the usage of TVWS channels.

40. In addition to the safe harbour channels, IDA understands that FCC has also developed a process to accommodate wireless microphone users who need more than the 2 channels for their operations (e.g. large scale events). These users will have to register with FCC to request for additional channels of operations with appropriate justifications, and upon approval from FCC, these users will have to register their wireless microphone operations with an authorised database. The users' wireless microphone information will then be propagated to the other authorised database, and these microphones will be designated as devices to be protected from interference in the white space spectrum.

41. Currently in Singapore, for large scale events where wireless microphones are to be used, the operational parameters are generally higher than those defined in IDA's technical specification for Short Range Devices[9]. As such, these wireless microphones are not considered as licence-exempt devices and organisers will have to apply for temporary licences for such wireless microphone operations. In this situation, these wireless microphones will be considered as licensed and hence eligible for protection in the white space spectrum, as defined in the previous section[10]. Therefore, IDA assesses that there may not be a strong need to develop a registration process similar to that of FCC's, to accommodate additional wireless microphone channels.

Question 16:
IDA invites views on its proposal for the protection of licence-exempt and licensed wireless microphones. IDA also invites views and comments on the optimal number of safe harbour channels required to ensure that licence-exempt wireless microphones can continue to be used once WSDs are deployed.

Question 17:
IDA invites views on the need to develop a registration process for users of licence-exempt wireless microphones that require additional channels beyond the safe harbour channels.

Cross-border Coexistence

42. IDA is of the view that a demarcation zone is the most straightforward option to manage coexistence with cross border TVWS deployments. This approach will also mitigate cross-border interference to broadcasting and other services in neighbouring countries. In IDA's proof-of-concept trials, a 7km demarcation zone was implemented

[9] http://www.ida.gov.sg/~/media/Files/PCDG/Licensees/StandardsQoS/RadiocomEquipStd/TSSRD.pdf
[10] The licensed wireless microphones operating in the TVWS spectrum is considered as an secondary services, as such the protection criteria will be similar to the one defined in the section "Coexistence of WSD with Secondary Services".

in the northern borders of Singapore and within this zone, WSDs are not allowed to operate in specific TVWS channels.

43. IDA intends to continue adopting this approach, but is considering to allow increased flexibility based on varying power transmission levels for the WSDs. Therefore, it is proposed that for WSDs operating in channels highlighted in Table 4, the coverage or signal propagated by the WSD to the northern borders of Singapore (marked in Figure 4), should not be above -120dBm. This demarcation is to indicate the area in which WSD signal emission is contained, and to ensure that the signals received at the neighbouring country will be below the noise floor level.

Table 4: Applicable TVWS Channels for the Demarcation Zone

Band	TV Channel	Frequency
VHF	11	216 - 223 MHz
UHF	25	502 - 510 MHz
	39	614 - 622 MHz
	41	630 - 638 MHz
	43	646 - 654 MHz
	45	662 - 670 MHz
	47	678 - 686 MHz
	49	694 - 702 MHz
	51	710 - 718 MHz
	53	726 - 734 MHz
	55	742 - 750 MHz
	57	758 - 766 MHz
	59	774 - 782 MHz
	61	790 - 798 MHz

Figure 4: Demarcation Zone for WSD Signal Propagation

44. This cross-border coexistence measure will be implemented through the authorised database. The demarcation zone will have to be outlined in the database and using the proposed propagation model defined in Paragraph 33, the database will compute the available channels as well as the maximum transmission power based on the limit of -120dBm.

Question 18:
IDA invites views on whether the proposed demarcation zone approach is sufficient in terms of managing cross border interference issue and if there are any other factors IDA should consider.

45. While straight-forward to implement, using a demarcation zone to protect the services in the neighbouring country does not maximise spectrum efficiency for Singapore. Spectrum efficiency can be improved by adding the locations of TV broadcast towers and receivers situated in the neighbouring countries into the national database of services that require protection from WSD. However, this would require extensive coordination effort, and IDA may consider this approach to be implemented over time into the database.

Aggregate Effects

46. Studies have been carried out to investigate the aggregate effect of multiple WSDs operating in a specific location. The conclusion was that the aggregate effect is not significant and regulators may not need to recommend a limit on the number of WSDs that can operate at any one location. As such, adjustment to the separation distances may not be necessary and the number of WSDs operating at one location will not affect the defined protection criteria.

Question 19:
IDA invites views on the aggregate interference effect of WSD and whether any adjustment in terms of technical requirement is needed.

Location Accuracy

47. The location of WSD must be of a high degree of accuracy in order to calculate the available spectrum in a given location for WSD, while guaranteeing protection from interference for primary and/or secondary users. Currently, there are three ways in determining the location of a WSD with varying degrees of accuracy. These are summarised in Table 5 as follows:

Table 5: Accuracy of Location-based Technology

Type of Location-based Technology	Accuracy
Global Positioning Systems	50 Metres
Cellular Base-station Triangulation	250 Metres
Wi-Fi	10 Metres

48. As most commercially available WSDs are equipped with GPS capabilities, this method is deemed the most cost-effective without having to incorporate additional functionalities into the WSDs. While the Wi-Fi based technique provides the highest accuracy, it is dependent on the availability and reliability of Wi-Fi networks in the location of the WSD. The cellular-based technique on the other hand, has the poorest accuracy, notwithstanding Singapore's nationwide deployment of cellular networks.

Question 20:
IDA invites views on using GPS as the method to determine location accuracy, and on whether 50m is a sufficient location accuracy requirement for the operation of WSDs.

49. IDA recognises that the use of GPS as the method to determine location accuracy may affect indoor operations of WSDs in Singapore. This is because the WSD is unlikely to receive a GPS signal when operating indoors, and therefore has no means of determining its location. As such, when operating indoors, Fixed Devices and Mode II Devices that can no longer receive a GPS signal will cease operation once the validity of white space channel expires.

50. To enable indoor WSD operations, IDA is considering allowing Fixed Devices to operate indoors under specific conditions. It is proposed that the location of a Fixed Device can be determined by either an incorporated geolocation capability or a professional installer. The geographical coordinates of a Fixed Device could be determined by the installer, at the time of installation and this information may be stored in the Fixed Device. In the event where the Fixed Device is moved to another location, the user shall re-establish the device's location.

51. To provide assurance that the manual input of geographical coordinates into a Fixed Device that is installed indoors is accurate, IDA proposes to allow only licensed or approved companies to conduct the installation. In IDA's view, it is critical to ensure accuracy of the location, as this affects the usage of white space spectrum and any error in the geographic coordinates may lead to possible interference issues with primary and/or secondary services.

Question 21:
IDA invites views on allowing the manual input and internal storage of geographic coordinates for indoor Fixed Devices.

Question 22:
IDA invites views on the requirement of an approval process for the installer of indoor Fixed Devices and the necessary conditions for approval.

PART V: TV WHITE SPACE NETWORKS

52. Currently, there are various TVWS applications deployed in Singapore under trial licences issued by IDA to companies who are interested in assessing the benefits of TVWS in complementing current wireless infrastructure. Due to the characteristics of VHF and UHF spectrum, TVWS technology is able to provide a wider coverage and higher penetration rate. As such, many countries are looking to this technology to support rural broadband applications. In Singapore, it is envisaged that TVWS technology will unlock additional spectrum capacity which will facilitate the provision of wireless broadband Internet access services, machine-to-machine connectivity, smart metering and outdoor environment or security monitoring networks.

53. In developing the TVWS regulatory framework, IDA intends to adopt an application-neutral and service-neutral approach. However, a greater understanding of the possible TVWS network topologies will assist IDA in developing a framework that will not restrict or limit the possible scenarios for the deployment and use of TVWS technology.

54. The types of network IDA envisages are highlighted below:

a) Fixed Device network, where all devices have geolocation capability and access to the database (Figure 5)

b) Master and Client Network, where only the master device (either a Fixed or Mode II Device) shall access the database and the client devices (Mode I Device) shall obtain the list of available channels from the master device (see Figure 6)

Question 23:
IDA invites views on the possible types of TVWS network topologies and use case scenarios.

Figure 5: Fixed Device Network

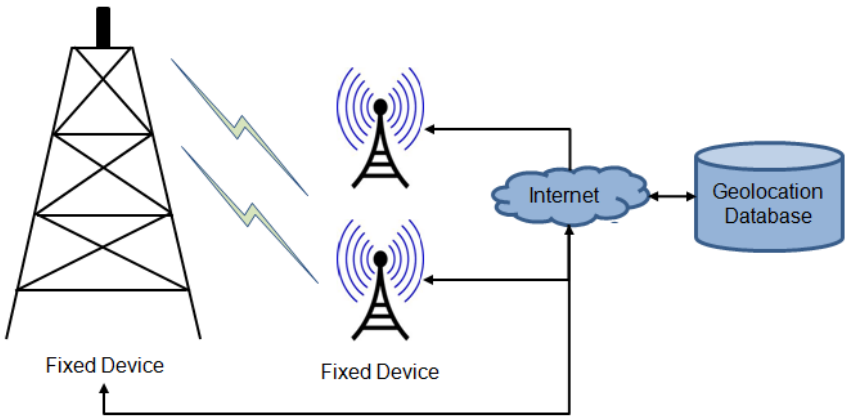
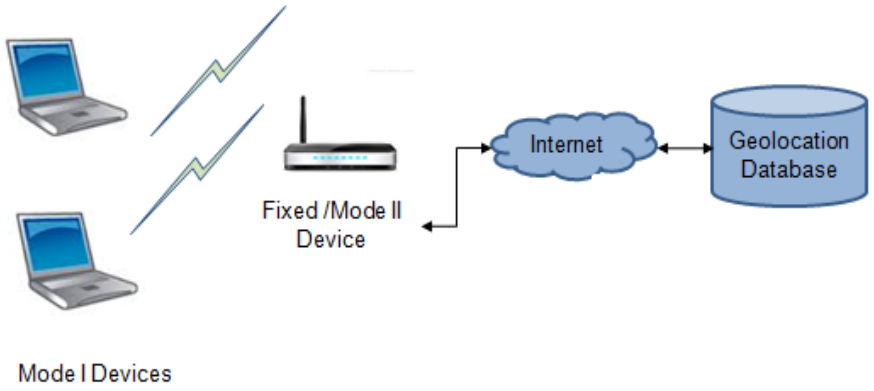


Figure 6: Master and Client Network



PART VI: MANAGEMENT OF GEOLOCATION DATABASE

Development and Maintenance of the Database

55. IDA is proposing to implement a database to protect primary and/or secondary services from harmful interference. The database will establish the protection contours based on separation distances defined in the previous section, to protect primary and/or secondary services.

56. We believe there are two approaches in the provisioning of a national database, one of which is the industry-managed approach which allows multiple industry players to develop and maintain their respective databases. The other option is for IDA to develop a government-managed database.

57. IDA expects a fair amount of resources will be required for the development and continual maintenance of the database. The database also needs to be scalable and reliable so that it can meet the demands of the queries from the WSDs. It is envisaged that for a government body to manage such a database, the cost of database management will have to be borne by TVWS users utilising this service. This may be implemented via the levy of a nominal fee on TVWS users, to recover the cost for database development and maintenance. This approach may provide a higher level of certainty for the TVWS users and greater certainty to businesses and consumers as opposed to a database administrator from the private sector.

58. However, IDA also notes that the functionalities of the database are likely to continue evolving over the next few years, and possibly include additional functionalities such as determining the quality of white space channels, interoperability between the WSDs and standardisation of communication protocols between database and WSDs. As these efforts are currently industry-driven, by allowing an industry-managed database may allow further innovation of the databases and in turn bring greater benefits to the TVWS ecosystem as a whole. Such an industry-managed approach is currently adopted by FCC and likely OFCOM as well, with FCC designating 10 database administrators and OFCOM requesting for the industry to submit proposals on the development of UK's database.

59. In both approaches, there will be differing benefits and impact to the industry. Key issues that have to be considered for the industry-driven approach include:

i) Industry interest and business continuity: IDA will have to assess the level of interest from companies who are interested in managing such a database in Singapore. While a single database may reap economies of scale for the database operator, having multiple database administrators may help facilitate business continuity for TVWS users, should any one of the database administrators choose to exit from the Singapore market.

ii) Business Models: Management of such a database will require resources and will need to be sustainable in the long term. As current business models and sustainability for database administrators are still unclear, there is a possibility that once this technology matures, database administrators may impose a fee on TVWS users for accessing their database. In such

cases, the issue of whether the fees that may be imposed on TVWS users would need to be subject to regulations will need to be considered.

Question 24:
IDA invites views on the payment of fees for the use of database services.

Question 25:
IDA invites views on both approaches in managing the database (i.e. industry-managed or government-managed database).

Question 26:
To better gauge the level of interest from the industry, IDA invites companies that are interested in developing and managing the database for Singapore to register its interest with us and share the following details:

i) Funding for database development and management (i.e. self-funded, cost recovery, etc)
ii) Business models considered when providing database services
iii) Possible fees involved for TVWS users

60. If an industry-driven approach is adopted, IDA proposes to specify certain conditions for the operation and administration of the databases. The following are the proposed preliminary key conditions for the database administrators:

a) Adopt a non-discriminatory approach (i.e. an "open" approach) that allows for any WSD to access the database;

b) Coordinate closely with IDA to ensure consistency and compliance with the relevant regulations;

c) Host their database servers in Singapore; and

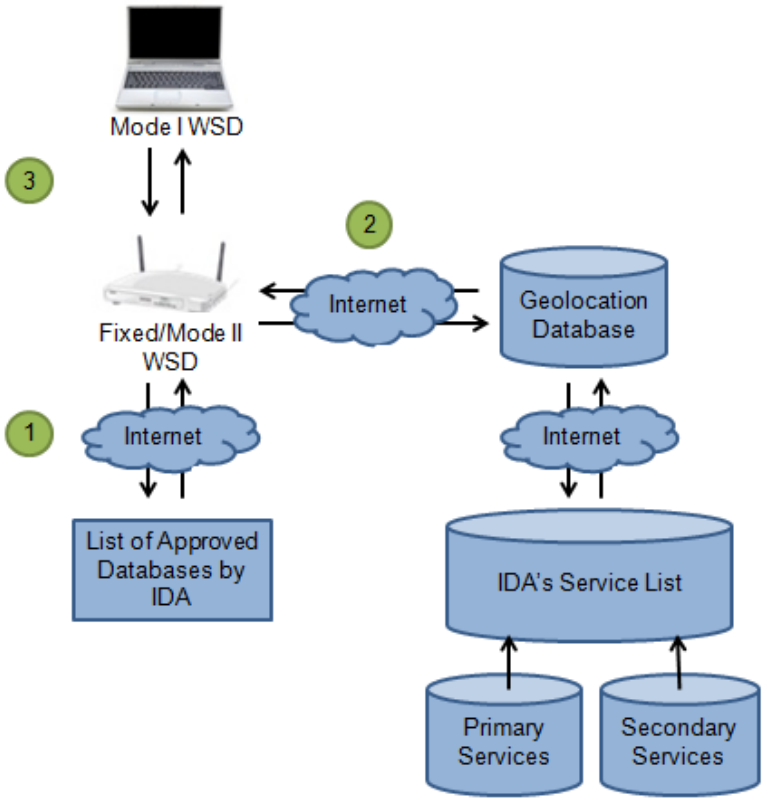
d) Abide by relevant laws and regulatory frameworks

Question 27:
IDA invites views on the proposed preliminary conditions for the operation and administration of the databases

Overview of Geolocation Database Operations

61. The interaction between the WSDs and an authorised database will minimally follow the sequence of operations illustrated in Figure 7. This sequence reflects the high level exchange of information between a Fixed/Mode II Device, an authorised database and the Mode I Device.

Figure 7: Sequence of Operations for a WSD



(1) Firstly, the Fixed/Mode II Device will have to consult a website which holds the list of IDA authorised database administrators. This process will ensure that there are no "rogue" WSDs in operation, since all devices are required to query the databases that have been authorised by IDA. IDA proposes to mandate secured communication between master WSD and the website holding the list of qualifying databases. Communications have to be performed using secure protocols to avoid malicious corruption and unauthorised modification of data, as well as ensuring that a WSD communicates with the correct website. This website will be hosted by IDA and it is possible that the website will be accessed using the HTTPS44 protocol.

(2) Secondly, once the Fixed/Mode II Device establishes the communication link with the authorised database to be used, communications between Fixed/Mode II Device and a database must be performed using secure protocols that avoid malicious corruption or unauthorised modification of the data. IDA expects that these security protocols will be established by technology standardisation organisations, one of which is the Protocol to Access White Space Database, or also commonly referred to as PAWS. Upon the establishment of communication between the Fixed/Mode II Device and the database, the database will return the list of available white space channels at the WSD location and the maximum transmission power limits. This transmission power parameter returned by the database has to be automatically stored by the WSD to avoid manual tempering of transmission level at the WSD device end.

(3) Lastly, for a TVWS network to be established, the Fixed/Mode II Device will send control signals via the available white space channels to another Fixed Device(s) or to a Mode I Device(s). Mode I Devices are allowed to begin transmissions only after establishing this command and control link.

Question 28:
IDA invites views on the proposed approach and communications protocols between the following:

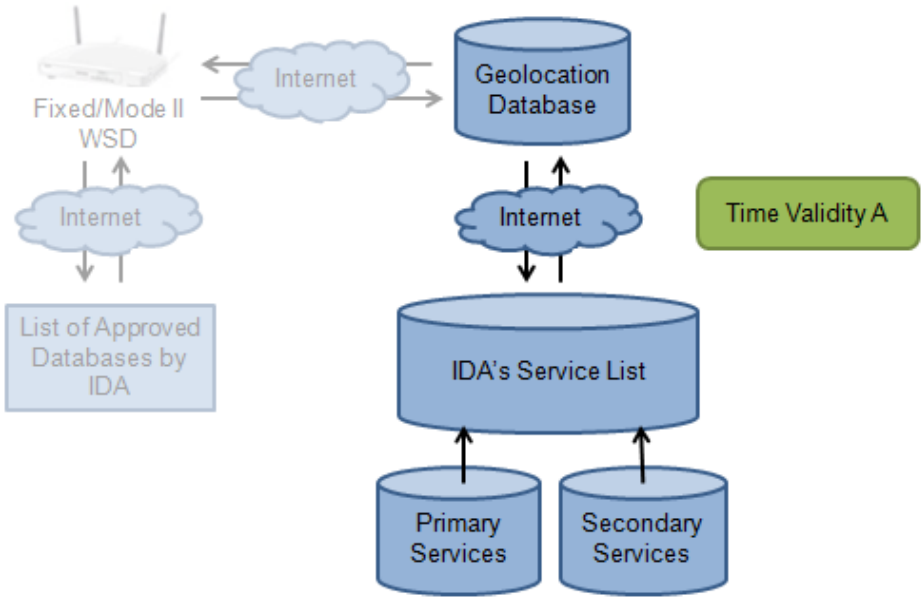
i) WSD and IDA website containing the list of authorised database administrators
ii) WSD and the database

Frequency of Geolocation Database Updates & WSD Queries

62. With the above sequence of operation, there are two query processes that require further analysis and establishment of a time validity factor. This time validity factor defines the frequency of update for the authorised database and WSDs, as described below:

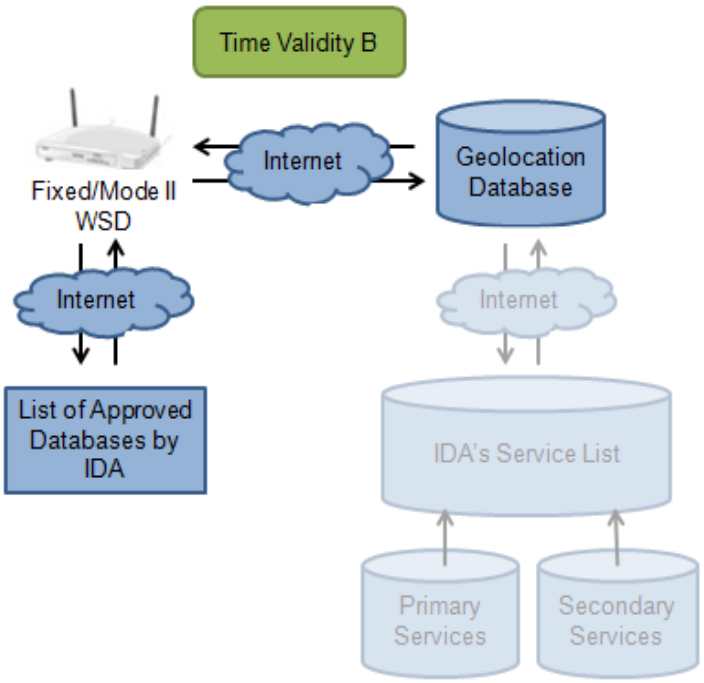
(1) Query between an authorised database and IDA's Service List (containing information on the primary and secondary services): IDA will be managing the list of primary and secondary services in the TVWS band. The authorised database is required to regularly query this service list for an update. This query is to ensure that any change in the list of primary and/or secondary service services will be captured in the authorised database. This change could be due to an issuance of temporary licence for wireless microphone services or change in operating location for PMR. Therefore, the time validity for this update process ("**Time Validity A**") should be relative to the dynamism and changes to these services in the white space spectrum.

Figure 8: Sequence of Update for a WSD



(2) Query between a WSD and an authorised database: A WSD will query an authorised database and from there select a white space channel for transmission. Upon the selection of a white space channel, there will be a time validity tied to this channel ("**Time Validity B**"). After the expiry of this validity period, the WSD will have to re-query the database for an updated list of available channels. The re-query process is to ensure that any changes in the list of primary and/or secondary services are taken into consideration when determining the list of available channels.

Figure 9: Sequence of Update for a WSD



63. In the event where there are changes in the list of primary and secondary services, and a newly licensed service occupies a channel being used by a WSD, the maximum time before a WSD needs to change its channel of operation will be the summation of both time validities. Firstly, the authorised database would have to query IDA's service list for an update after the expiry of Time Validity A. Secondly, when Time Validity B expires, the WSD will then query the updated authorised database for an updated list of available channels. Only after completion of these two processes will the WSD change its channel of operation to avoid interference with the primary and/or secondary service.

64. Based on the dynamism of the white space spectrum and the small geographic location of Singapore, IDA is of the view that the time validity of 6 hours for each process is appropriate. With this arrangement, the maximum time before a WSD needs to switch channel to avoid interference with a primary and/or a secondary is 12 hours.

65. However, IDA is considering including a parameter within the authorised database and WSD that will allow adjustment of the value of both time validity factors, according to the operational circumstances.

i) Time Validity A: It is proposed that the value of Time Validity A to be incorporated as part of IDA's Service List that will be downloaded by the authorised database. After the expiry of this time factor, the authorised database will have to update itself.

ii) Time Validity B: It is proposed for the value of this time factor to be listed in the IDA website containing the list of authorised databases. The WSD accessing this website would then have to download and store this value within its system.

66. With this flexibility of adjusting the frequency of update, some clarity of the time range will be necessary. IDA understands that requiring the WSD to query the database frequently would require extensive server resources. As such, IDA proposes that a reasonable time range is between 6 to 12 hours (i.e. summation of both time validity factor to be within this range).

Question 29:
IDA invites views on the proposed frequency of update for Time A validity and Time B validity.

Question 30:
IDA invites views on requiring the adjustment of the value for Time A validity and Time B validity, and for this to be within the range of 6 to 24 hours.

Registration of WSD in the Database

67. In the last consultation document released by OFCOM in Nov 2012, titled "TV white spaces"[11] it was proposed that the database maintain a record of actual usage of the WSDs. This requires WSDs to report its selected channel for use and transmission power back to the database. IDA recognises the benefits to this approach, as it allows any interfering WSD to be easily identified and provides clarity on the utilisation of TVWS at specific locations. However, to implement such an approach, additional resources at the database-end to process and store operational information of every WSD may be required. IDA would like to solicit feedback from the industry to weigh the benefits and trade-offs, and assess the need to include the WSD reporting function into regulatory framework.

Question 31:
IDA invites views on the benefits and costs of a requirement for WSD to report its operational parameters to the database.

68. At a minimum, IDA intends to require all WSDs querying the database to register its unique identifier and operating location with the database. However, as Fixed Devices could operate at a higher power beyond 100mW, IDA assesses that it is necessary for such devices to register with the database and provide

[11] http://stakeholders.ofcom.org.uk/consultations/whitespaces/

comprehensive contact information. Should any interference issue related to these Fixed Devices arise, IDA will then be able to contact the user or operator of the system to take the necessary corrective actions. The contact information will include, but is not limited to the following:

- Unique Device Identifier
- Device's geographic coordinates (latitude and longitude)
- Name of individual or business that is responsible for the device
- Name of a contact person responsible for the device's operation
- Address, email address and phone number for the contact person

Question 32:
IDA invites views on the benefits of including within the TVWS regulations a requirement for WSD to register its contact parameters to the database.

PART VII: INVITATION TO COMMENT

69. IDA would like to seek the views and comments from the industry and members of the public on its proposed regulatory framework for WSDs.

70. All views and comments should be submitted in writing and in both hard and soft copies (Microsoft Word Format), and should reach IDA by **16 September 2013**. Respondents are required to include their personal or company particulars, correspondence address, contact number and email address in their submissions. IDA reserves the right to make public all or parts of any written submission and to disclose the identity of the source. Commenting parties may request confidential treatment for any part of the submission that the commenting party believes to be proprietary, confidential or commercially sensitive. Any such information should be clearly marked and placed in a separate annex. If IDA grants confidential treatment it will consider, but not publicly disclose, the information. If IDA rejects the request for confidential treatment, it will return the information to the party that submitted it and will not consider this information as part of its review. As far as possible, parties should limit any request for confidential treatment for information submitted. IDA will not accept any submission that requests confidential treatment of all, or a substantial part, of the submission. 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 the Proposed Regulatory Framework for TV White Space Operations in the VHF/UHF Bands” via email to IDA_consultation@ida.gov.sg.

Annex A

Coexistence of WSD with Secondary Services
Computation Methodology

1. The maximum transmission power of a WSD is computed based on the following scenario and sequence:

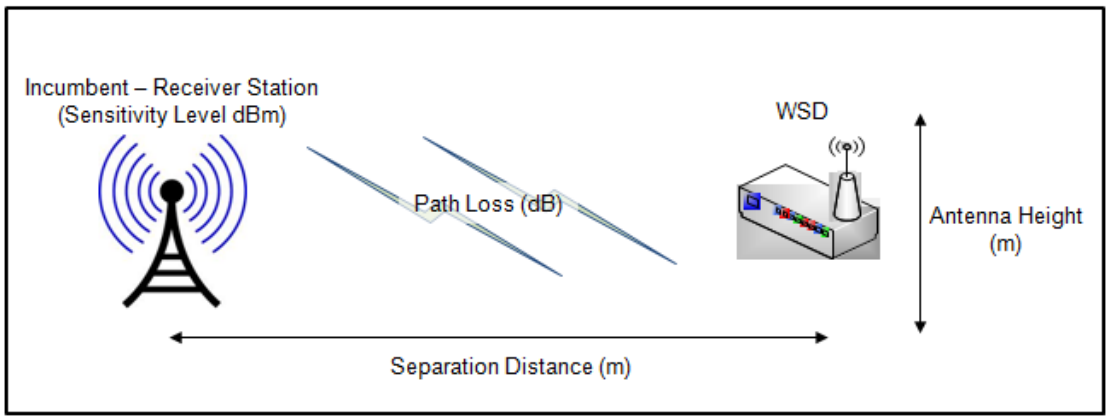
(1) Determine the separation distance: The WSD will have to inform the database of its operating location and height of its transmitting antenna. Using the location information, the database will determine the separation distance between the WSD and the secondary receiver station.

(2) Determine the path loss: With the separation distance, the database will compute the path loss using the Hata propagation model.

(3) Determine the maximum transmission power: Following that, the database will compute the maximum transmission power of the WSD, ensuring that the signal level reaching the secondary receiver station will be at noise floor level to avoid any interference issue.

(4) Return of information to the WSD: The database will then return spectrum availability information to the WSD, together with the maximum transmission power level for each channel.

Figure 1: Scenario used to Compute the Maximum Transmission Power of a WSD



2. The table below provides the range of transmission power of a WSD with varying separation distances.

Table 1: Maximum Transmission Power of a WSD

	VHF	**UHF**
Separation Distance between a WSD and Secondary Services	**Maximum dBm/channel for WSD**	
1000m	-6	5
2000m	5	16
3000m	11	22

	VHF	UHF
Separation Distance between a WSD and Secondary	**Maximum dBm/channel for WSD**	
4000m	15	27
5000m	19	30
6000m	22	33
7000m	24	35
8000m	26	37
9000m	28	39
10000m	29	41
11000m	31	42
12000m	32	43
13000m	33	45