



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

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

16 June 2014

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PART I: INTRODUCTION

1. Radio frequency spectrum is a limited resource. IDA estimates that between 1 GHz and 2 GHz of spectrum will be required to deliver mobile broadband services by around 2025, depending on the demand scenarios. IDA continues to review the allocation of spectrum to ensure the optimal use of scarce spectrum resources, and to facilitate IDA's vision of establishing Singapore as a 'Smart Nation'¹. Our vision of a 'Smart Nation' is underpinned by a high speed, trusted and resilient infocomm infrastructure, comprising fixed and wireless networks. In particular for wireless networks, we are planning to facilitate the deployment of a Heterogeneous Network ("HetNet") which will allow seamless transition between mobile and wireless networks for end users. Hence, IDA's overall plans and initiatives for spectrum allocation will take into account the technological trends and developments in the mobile and wireless space.
2. One key technology trend gaining momentum around the world is the adoption of new technologies such as Dynamic Spectrum Access ("DSA") to improve the way wireless devices are currently accessing spectrum resources to make more efficient and optimal use of the existing frequency bands. DSA is a form of spectrum sharing technique that enables the opportunistic use of under-utilised spectrum in certain spectrum frequency bands on a temporal and spatial basis.
3. A possible application of DSA lies within the television broadcast channels, specifically in the Very High Frequency ("VHF") and Ultra High Frequency ("UHF") bands. Due to the transition of broadcasting services from analogue to digital services, under-utilised spectrum within these bands that are primarily being used for television broadcast services, could be made available for other wireless telecommunication services. This untapped source of spectrum, known as "TV White Spaces" ("TVWS"), is well placed to increase the capacity of wireless bandwidth and enable wireless data connectivity for services such as wireless broadband Internet access, machine-to-machine ("M2M"), smart metering, and outdoor environment and security monitoring services.
4. Currently, IDA adopts two approaches to allocating radio spectrum. Depending on the frequency bands, competing demand for and supply of spectrum, IDA will allocate spectrum either through an administrative process or through auction. Both methods of allocation would give the users primary access to the spectrum and in some cases on an exclusive basis. However, with TVWS technology, IDA will be adopting an innovative approach to unlocking and harnessing under-utilised spectrum and allow shared use on a geographic and time-limited basis.
5. IDA issued a public consultation on its proposed regulatory framework for TVWS operations in the VHF/UHF bands ("**Consultation**") on 17 June 2013. Views were sought on the licensing framework for the operation of White Space Devices ("**WSDs**"), and the approach to facilitating coexistence between WSDs and protected

¹ IDA's vision of a 'Smart Nation' encompasses citizens and people at the core of the transition – to use infocomm to enhance and improve citizens' lives and ensure that the use of infocomm is maximised to its fullest potential for the benefit of Singapore.

services² operating in the VHF/UHF bands (“**protected services**”), which included factors such as the operational parameters for WSDs, protection criteria and the development of a TVWS geo-location database.

6. By the close of the Consultation on 16 September 2013, IDA received comments from the following twenty-one respondents (“**Respondents**”):

- a) Ericsson;
- b) GSM Association (“GSMA”);
- c) iConectiv;
- d) IDA Telecommunications Standards Advisory Committee Work Group 6;
- e) Institute for Infocomm Research;
- f) Institute for Infocomm Research and SP Power Grid Ltd;
- g) InterDigital Inc;
- h) LS Telcom AG;
- i) M1 Limited;
- j) Mediacorp Pte Ltd;
- k) Microsoft Corporation, Mediatek Inc and 6 Harmonics Inc;
- l) Motorola Solutions;
- m) National Institute of Information and Communications Technology;
- n) Neul Limited;
- o) Power Automation;
- p) Qualcomm Incorporated;
- q) Sennehiser Electronic GmbH & Co KG, Germany;
- r) Singapore Telecommunications Limited;
- s) Singapore White Space Pilot Group
- t) Spectrum Bridge; and
- u) Starhub Group.

² Generally, these protected services in the VHF/UHF band are the TV broadcasting services, Private Mobile Radio and wireless microphones services. These protected services were referred to as incumbent primary and secondary services in the Consultation. IDA may include other services in the future.

7. IDA thanks all Respondents for their comments. IDA notes that the Respondents were generally supportive of the framework, but have provided some suggestions on how it could be improved. This paper discusses the key issues raised for Consultation, comments received from Respondents, and IDA's Decision on the final regulatory framework.

8. To facilitate better understanding of IDA's decision on the TVWS framework, Part II of this paper provides a summary of key industry comments, IDA's responses to these comments and IDA's corresponding decisions, while Part III provides the finalised TVWS regulatory framework and technical details.

PART II: SUMMARY OF INDUSTRY RESPONSES AND IDA'S DECISIONS ON KEY RESPONSES

Spectrum Band for TVWS Technology Deployment including the Use of the 700MHz Band

9. **Background:** In the Consultation, IDA had proposed parts of the VHF spectrum between 174 MHz and 230 MHz, and the UHF spectrum between 470 MHz and 806 MHz for TVWS operations. Currently, these two spectrum bands are allocated for the provision of broadcast and other services, but these services do not fully utilise all the VHF and UHF channels at all times and in all locations. As such, these unused channels could potentially be utilised for TVWS operation and deployment.

10. Within the UHF band is the 694MHz to 806MHz band, also known generally as the 700MHz band, which has been earmarked for International Mobile Telecommunications (“**IMT**”) services in Singapore. Although this band has been harmonised regionally, IMT services will likely operate in the 700MHz band only after the Analogue TV Switch Off³ (“**ASO**”), which is currently planned to take place by 2020 in Singapore. As such, IDA had sought the industry’s view on the possible use of the 700MHz band in the interim period before ASO.

11. **Summary of Response:** Most respondents were supportive for spectrum in the proposed VHF and UHF bands to be made available for TVWS technology deployment. Half of the Respondents were supportive of IDA’s proposal to include the 700MHz band in the interim before ASO for TVWS technology deployment. However, some of the Respondents were opposed to such an arrangement as they were concerned that it might affect the eventual deployment of IMT services in the 700MHz band. There were concerns that there would be difficulty in migrating the WSDs out of this band when the time came to deploy IMT services in this band.

12. **IDA’s Views and Decision:** The main objective in allowing the deployment of TVWS technology in parts of the VHF and UHF spectrum band is to exploit the under-utilised spectrum for alternative use. Although the 700MHz band (694 – 806MHz) is earmarked for IMT services, this spectrum band can only be allocated for IMT services after ASO, which is likely to take place by 2020. Therefore, it would not serve the purpose of encouraging efficient and optimal use of spectrum if IDA prevents the use of the 700MHz band in the meantime and reserves it for IMT services deployment in the future. IDA notes that the Office of Communications (“**OFCOM**”) in the UK had also proposed to open up the 700MHz band for TVWS use, until this band is internationally harmonised and ready to be allocated for IMT services.

13. To address the mobile industry’s concerns of interference between WSDs and the IMT services in the 700MHz band, IDA will undertake the following when the 700MHz band is ready to be allocated for IMT services:

- a) Vacate the WSDs from the 700MHz band – this can be achieved by removing these channels from the geo-location database and providing early notice to the industry to make the operational adjustments; and

³ For more information, please refer to <http://www.mda.gov.sg/PublicEducation/DigitalTvConsumers/Pages/Overview.aspx>.

- b) Conduct radio monitoring scans to ensure that there are no wireless operations in the 700MHz band.

14. With the inclusion of the 700MHz band for TVWS deployment, the amount of VHF/UHF TVWS spectrum and channels before and after ASO will vary slightly as shown in Table 1 below.

Table 1: TVWS Channels Before and After ASO

	<u>TVWS Channels*</u>	<u>Total No. of Channels</u>	<u>Total Bandwidth</u>
Before ASO	i) 181 - 188MHz (Channel 6) ii) 209 - 223MHz (Channel 10 and 11) iii) 502 - 518MHz (Channel 25 and 26) iv) 614 - 622MHz (Channel 39) v) 630 – 710MHz (Channel 41 to 50) vi) 718 – 742MHz (Channel 52 to 54) vii) 750 – 774MHz (Channel 56 to 58) ix) 790 - 806MHz (Channel 61 and 62)	3 VHF channels; and 21 UHF channels	189MHz
After ASO	i) 174 - 188MHz (Channel 5 and 6) ii) 195 – 202MHz (Channel 8) ii) 209 - 230MHz (Channel 10 to 12) iii) 470 - 534MHz (Channel 21 to 28) iv) 614 - 694MHz (Channel 39 to 48)	6 VHF channels; and 18 UHF channels	186MHz

*Note: Some channels may be blocked from TVWS operations to better avoid interference with the protected services. Details are set out in Part III of this document.

Geo-location Database Approach as the Mandated Method for TVWS Spectrum Access

15. **Background:** Spectrum sensing and geo-location databases (“**Geo-location Database**”) are currently the only two methods to manage and ensure non-interfering access to TVWS spectrum. However, as spectrum sensing technology is still at a nascent stage of development, there is global consensus on the use of the Geo-location Database method to manage access to TVWS spectrum. IDA had recommended that Singapore adopt the TVWS Geo-location Database method as the mandated method for WSDs to access TVWS spectrum.

16. **Summary of Response:** The Respondents were generally supportive of using the Geo-location Database method as the mandated method to access TVWS spectrum. However, some of the Respondents suggested that IDA include the spectrum sensing method as either another mandated approach, or a complementary measure, for the Geo-location Database. These Respondents were of the view that spectrum sensing technology was sufficiently developed and it could be relied upon to ensure coexistence with protected services or enhance the accuracy of the Geo-location Database service.

17. **IDA's Views and Decision:** IDA notes that the sensing technology has been explored in many overseas jurisdictions, but it is not a mature technology and it has yet to be mandated for adoption by these jurisdictions, including the US Federal Communications Commission (“**FCC**”) and the OFCOM in the UK. This is consistent with the results of IDA's Cognitive Radio Venue (“**CRAVE**”) trials, which studied the feasibility of using sensing technology as the primary means of accessing the TVWS spectrum. The findings showed that with the high noise floor level in Singapore, sensing technology is not an appropriate method for WSDs to access TVWS spectrum at this juncture. As such, IDA will adopt the Geo-location Database approach as the mandated method for WSDs to access TVWS spectrum. However, IDA encourages the industry to continue to explore the area of spectrum sensing and IDA will allow spectrum sensing to be used as a complementary measure, so long as it does not cause interference issues to other devices and users⁴.

18. The licensing arrangement for the management of the Geo-location Database is highlighted in Paragraphs 84 to 89 of this document.

Licensing Framework for White Space Devices

19. **Background:** IDA had proposed that three categories of WSDs be allowed in Singapore, these ranged from high to low power WSDs and fixed to portable WSDs, as summarised below:

- a) A Fixed WSD would refer to a device that would be operating in a fixed geographic location and with a maximum transmission power of 4W EIRP.
- b) A Mode I WSD would refer to a device that would be operating on a portable basis, in conjunction with a Fixed or Mode II WSD, and with a maximum transmission power of 100mW EIRP.
- c) A Mode II WSD would refer to a device that would be operating on a portable basis and with a maximum transmission power of 100mW EIRP.

20. The FCC and OFCOM have allowed WSD operations on a licence-exempt basis. In the Consultation, IDA had proposed adopting the same approach to facilitate the adoption of TVWS technology in Singapore. This means that WSD operations do not need a station/network licence and no spectrum fee is required; subject to the conditions set forth by IDA⁵.

21. **Summary of Response:** The Respondents were generally supportive towards adopting a licence-exempt approach for the operation of WSDs, subject to regulatory and technical conditions set by IDA. However, some Respondents recommended that IDA consider using a Licence Shared Access (“**LSA**”) approach for the following reasons: (i) possible interference to existing or planned broadcasting and mobile services; and (ii) competition between licence-exempt TVWS and licensed mobile

⁴ As the Geo-location Database provides the WSD with information on available TVWS spectrum to ensure that it will not cause interference with the protected services, spectrum sensing information can be used to protect WSD from interfering with each other.

⁵ 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. The conditions for licence-exemption will be defined in the Exemption Notification and the technical specification document. Although the operation of WSDs in the TVWS spectrum will be licence-exempt, the provision of public telecommunication service using WSDs will still be subject to licensing.

broadband applications/deployment. Some Respondents were of the view that mobile operators faced expensive acquisition costs for licensed spectrum and regulatory obligations on quality of service, tariffs and coverage, amongst others, while market players who aimed to address the same market as the incumbent mobile operators' by utilising licence-exempt spectrum would not face the same burden, and might enjoy an unfair cost advantage.

22. **IDA's Views and Decision:** While IDA notes the concerns of some of the Respondents, IDA believes that adopting a licence-exempt approach will allow users to explore a range of business models, enable more innovative services to flourish and encourage the adoption of the technology. IDA notes that the licence-exempt approach towards Wireless Local Area Networks such as WiFi has encouraged their widespread use and provided much benefit to consumers and business users. While market players that leverage on a licence-exempt spectrum band may face less radio spectrum acquisition costs and regulatory obligations, there are also trade-offs faced by these market players. For instance, the operation of these networks or equipment in the licence-exempt spectrum band will be on a non-exclusive and an unprotected basis. Additionally, these operations are not offered assurance of spectrum availability as compared to those operating on licensed spectrum bands. On the suggested LSA⁶ approach, IDA notes that it is a concept that is still being developed, requires further study and is not ready for adoption. Mobile operators who have obtained radio spectrum from IDA for exclusive use are not precluded from deploying TVWS technology and WSDs to complement their existing suite of services.

23. With regard to the concerns on potential interference issues, IDA would like to assure the industry that the regulatory framework developed by IDA is designed to ensure coexistence between WSDs and the protected services. This coexistence method will be managed through the use of a Geo-location Database and technical parameters established by IDA for co-channel and adjacent channel use. IDA has assessed⁷ that these parameters are sufficiently stringent to mitigate the risk of interference to the protected services. Also, IDA would like to reiterate that under the TVWS framework, WSDs will be operating on a licence-exempt basis, which means they will be sharing the spectrum with other users (i.e. non-exclusive) and they will not be offered protection from interference (i.e. unprotected). If, for any reason, the WSD has caused interference to the protected services, the WSD will have to be turned off, or moved to another non-interfering channel.

24. Dealers and equipment suppliers will have to register their WSDs with IDA under the General Equipment Registration ("**GER**") scheme. More information about this scheme is provided in Paragraphs 38 to 39 of this document.

⁶ LSA was first adopted by Nokia and Qualcomm as a concept to capture a situation in which two or more users are authorised to utilise the same spectrum band on a non-exclusive basis in a defined sharing arrangement. However, this concept is still in the developmental stage, and the European Telecommunications Standards Institute ("**ETSI**") is currently working on standardising the Authorised Shared Access ("**ASA**")/LSA technology.

⁷ Assessment was based on noise floor measurements in Singapore, insights from local trial and technical reports conducted by other regulators.

Designation of Channels for Services Requiring Certainty of TVWS Spectrum Access

25. **Background:** Through IDA's initial engagement with the industry, it was highlighted that one key concern with adopting a licence-exempt approach for WSDs was the lack of guaranteed spectrum availability. The industry had earlier feedback that this might pose a barrier to the deployment of services that might require greater certainty of spectrum access, for example, those services requiring higher-level of reliability and more real-time transmission. To address this concern, IDA had sought views on the possibility of setting aside or designating some channels within the TVWS spectrum for priority access, to support the deployment of such services.

26. **Summary of Response:** Most respondents were supportive of IDA's proposal to set aside or designate some channels in the TVWS spectrum for priority access to provide certainty to those services that require them. The Respondents highlighted that priority access mechanisms could be supported by the Geo-location Database structure; allowing high priority users to access at least a portion of the spectrum quickly on an urgent but ad-hoc basis.

27. **IDA's Views and Decision:** It is important to emphasise that as TVWS operations will be on a licence-exempt basis, the use of TVWS spectrum will be on an unprotected and a non-exclusive basis. Companies that are providing critical services that require high-level of reliability and real-time transmission, or that are used for public safety purposes, should consider using licensed spectrum (which may provide for exclusive and protected use) instead of TVWS.

28. Nonetheless, to meet the needs of companies/users who wish to explore using TVWS technology to provide services that require a relatively higher level of spectrum availability and access, IDA will designate two High-Priority Channels ("HPCs") within the TVWS spectrum for such use. In the event that all common TVWS channels are exhausted or when there is limited availability of common TVWS channels, TVWS users will have an option to choose to access the HPCs. Such access may be provided as a premium service by the Geo-location Database providers. IDA will allow the Geo-location Database providers to commercially determine the management of the HPC access, including the appropriate allocation mechanism⁸.

29. IDA recognises that the allocation and management of HPC could be a business opportunity for Geo-location Database providers. It will also provide the market greater business and user options in adopting and applying the TVWS technology. Interested Geo-location Database providers should coordinate amongst themselves to synchronise the HPC usage and to ensure coexistence of WSDs using the HPCs. Interested Geo-location Database providers should also inform IDA of its allocation mechanism.

30. While IDA will set aside two channels as HPCs to allow industry players to explore market possibilities as a start, IDA notes that there is no precedence of HPCs for TVWS operations. IDA will thus monitor the utilisation of these channels and if necessary, IDA could increase or decrease the number of HPCs over time depending on market demand.

⁸ Some possible mechanism the Geo-location Database providers could adopt for HPC allocation could be on a first-come-first serve basis, bidding or entering into a business agreement.

Geo-location Database Query Scenarios

31. **Background:** IDA envisages that WSDs querying the Geo-location Database will receive a list of available white space channels that they could operate in, subject to the corresponding maximum transmission power limits. In a situation where a WSD is unable to establish contact with an authorised Geo-location Database or when the authorised Geo-location Database becomes unavailable, the WSD must cease transmission. To minimise the risk of interference, it was proposed in the Consultation that WSDs would query the Geo-location Database and request up-to-date information in the following situations (i) when the WSD had just powered up; (ii) when the WSD had moved away from its original physical location considerably, in this case ≥ 50 metres from its original location; or (iii) when the time validity of the WSD's operating channel had lapsed.

32. **Summary of Response:** In total, eight of the Respondents expressed concern that the proposed 50 metres limit was overly stringent and requested that IDA relax the limit to 100 metres instead. Relaxing this requirement would reduce the amount of traffic generated through Geo-location Database queries and minimise transactional overheads, which would reduce the cost of operating Geo-location Databases significantly. Aside from the 50 metres limit, Respondents had also suggested that an option be provided to perform advanced querying of the Geo-location Database. This would allow WSDs to acquire information on TVWS channel availability in neighbouring areas or for a larger area so as to increase efficiency and mobility for WSDs.

33. **IDA's Views and Decision:** Based on the responses, IDA notes that the industry is agreeable to the proposal to require the WSDs to query the Geo-location Databases in the following situations: (i) when the WSD is powered up; or (ii) when the time validity of the WSD's operating channel has lapsed. In the Consultation, IDA had proposed a 50 metres limit as a more stringent condition. It is also technically feasible since the in-built geo-location accuracy of commercial WSDs is within ± 50 metres. However, IDA is agreeable to the industry's proposal to increase the 50 metres limit to 100 metres, and notes that it is in line with the Geo-location Database query requirements set by FCC. Amending the query limit to 100 metres will increase the Geo-location Database efficiency, as it will have to manage fewer queries. In addition, since most mass market and commercially ready products are aligned to the FCC and OFCOM requirements, having a 100-metre limit will reduce the need for equipment manufacturer to modify the functionality of the WSD for Singapore's operations and create economies of scale.

34. With regard to enabling mobility for WSDs (i.e. Mode II WSDs), IDA agrees that advanced querying of the Geo-location Database for multiple locations should be allowed for Mode II WSDs. As such, IDA will allow Mode II WSDs to query the Geo-location Database for channel availability and maximum transmission power information for multiple locations around its current location, and use that information in its operation. With such an approach, a Mode II WSD will be able to transmit within a small geographic area until the validity of the operating channels has lapsed (for information on the validity period, see Section on Frequency of Geo-location Database Updates & WSD Queries).

Technical and Operational Parameters of WSD

35. **Background:** IDA had proposed to align the permissible transmission output power of WSDs in Singapore with commercially-ready products, which was to allow a maximum of 4W EIRP for Fixed WSDs and 100mW EIRP for Mode I and II WSDs. This is similar to the permissible transmission output power adopted by the FCC. To allow flexibility and increased access to white space spectrum, IDA proposed to allow a tuneable transmission power for Fixed WSDs to be capped at 4W EIRP. The permissible transmission power of the Fixed WSDs will be determined by the Geo-location Database, which will be dependent on the protection criteria defined by IDA, the antenna height and the location of the WSD.

36. **Summary of Response:** The Respondents have differing views on the maximum permissible transmission power of WSDs. Some Respondents commented that the proposed transmission level was too high and suggested that it should be capped at 1W EIRP instead. Others were of the view that the maximum transmission power of 4W EIRP should be increased as it would be beneficial for certain uses such as long range point-to-point communications. Respondents who supported the proposal believed that WSDs should, by regulation, be encouraged to use the minimum power necessary to avoid unnecessary interference. Such an approach would introduce flexibility in the sharing of TVWS spectrum and maximise the use of TVWS spectrum.

37. **IDA's Views and Decision:** In an urbanised environment such as Singapore, if the permissible transmission power level is set too low, it will limit the types of TVWS applications that could be deployed and this will create a barrier for TVWS technology adoption. Similarly, IDA is also cautious about increasing the maximum allowable power level during these early stages of TVWS technology deployment, especially since 4W EIRP is also the maximum power level that is adopted by regulators in the US and UK. IDA is of the view that the proposed coexistence approach with protected services is sufficiently stringent to mitigate interference issues. Therefore, IDA believes that a maximum of 4W EIRP for Fixed WSDs and 100mW EIRP for Mode I and II WSDs are about the right level and will maintain these as the permissible transmission output power.

38. All WSDs will be required to be validated in accordance with IDA's equipment conformance framework. This will allow IDA to regulate the sale of telecommunication equipment via its licensees and take enforcement action, when necessary. Equipment that does not meet the respective technical standards will not be permitted for sale in Singapore.

39. As WSDs are considered a new technology and there is potential for causing interference, IDA will adopt the GER scheme as this will entail a comprehensive validation process. Equipment suppliers are required to submit equipment certification (i.e. declaration certified by an IDA recognised body); or relevant test reports and supporting documents for the model of equipment (i.e. declaration will be evaluated by IDA).

Unique WSD Identifier

40. **Background:** The purpose of a unique WSD Identifier is to enable the Geo-location Database to uniquely identify a WSD. The FCC has implemented such an identification mechanism through the FCC Identifier and manufacturer serial number in their TVWS regulations. IDA was of the view that such an identifier would be necessary but this should ideally be internationally harmonised. This issue is currently being addressed through the European harmonised standard under development by the European Telecommunications Standards Institute (“**ETSI**”) for Broadband Radio Access Networks (“**BRAN**”).

41. **Summary of Response:** The majority of the Respondents supported the proposed idea. Most of the Respondents suggested that standardised identifiers would clearly be preferred and this was also supported by the IETF Protocol to Access White Space (“**PAWS**”), which defined the communications between a WSD and a Geo-location Database.

42. **IDA’s Views and Decision:** Having a unique WSD Identifier will facilitate device level security/authentication and enable the Geo-location Database to uniquely identify and disable certain WSD that may be a source of interference. We agree with the Respondents’ view that this identifier should be based on standards developed by recognised standards organisations (e.g. ETSI, IEEE, etc) or based on a regulator-defined format (e.g. FCC defined identifier). This will drive down the costs of WSDs, increase adoption, and at a later stage facilitate roaming with cross-border Geo-location Databases. It is anticipated that commercially available WSDs will either have ETSI or FCC based identifiers during the early stages of WSD adoption. To ensure WSD interoperability and for ease of tracking, IDA will require the Geo-location Database providers to incorporate the flexibility to accept and store different types of Unique WSD Identifier.

Coexistence of WSD with Local Broadcast Services

(i) Adjacent Channel Operation – WSD Power Level

43. **Background:** Given the small geographical area in Singapore, to avoid frequency interference, IDA had proposed in the Consultation that spectrum used for local television broadcast would not be made available for WSD operation. Only spectrum not used for local television broadcast would be made available. As such, a WSD would normally operate in channels adjacent to that of local broadcast services, and the coexistence parameters for WSD deployment would therefore focus on adjacent channel operations between a WSD and local broadcast services. IDA had proposed that only Mode I and II WSDs be allowed to operate in the adjacent channels because these would be low power WSDs that would unlikely cause interference to the broadcast services. The permissible power transmission limits for these WSDs in the adjacent channels would be capped at 100mW EIRP.

44. **Summary of Responses:** The majority of the Respondents supported the proposal to allow only 100mW WSDs to operate in the channels adjacent to the local broadcast channel. However, some Respondents were of the view that the 100mW transmission power limit would still be too high, while another opined that the restriction should be on the transmission power limit, regardless of the type of WSD.

One Respondent stressed that WSD operations should not be permitted in the immediate adjacent channels ($N\pm 1$). It was also recommended that further studies be conducted to validate the possibility of WSD operations at two channels away ($N\pm 2$).

45. **IDA's Views and Decision:** Singapore's free-to-air ("FTA") TV channels have begun broadcasting in digital format on 16 December 2013, where the transmission network is built for indoor reception. Digital TV signal reception will generally be weaker for indoor receivers, and this may result in mutual interference between the Digital Video Broadcasting – Second Generation Terrestrial ("DVB-T2") set-top boxes and WSDs. Thus, stringent adjacent channel operations have to be put in place to ensure coexistence between the DVB-T2 set-top boxes and WSDs, and ensure that there will not be interference to digital broadcast services. As a start, IDA will not allow WSDs to operate in the two channels that are adjacent to digital broadcast services. As such, Channels 25 and 26 which are adjacent to digital broadcast service channels will not be permitted for WSD operations and this will be managed through the Geo-location Database. In addition, a maximum power level of 100mW will be set for WSD operation in the channels adjacent to the local analogue broadcast service channels. Should further tests demonstrate that coexistence is possible in these two channels, IDA may release these channels for TVWS usage.

Adjacent Channel Operation – Out-of-Band ("OOB") Emission Limit

46. **Background:** In the Consultation, IDA proposed that the OOB emission limits for WSDs operating in channels adjacent to broadcast channels should not exceed -56.8dBm. As this was in line with the OOB emission limits defined by the FCC, it would be likely that there would be commercially available WSDs that would meet the proposed OOB emission requirements. For WSD operating in TVWS channels that were not adjacent to local broadcasting channels, IDA was of the view that there was no need to define OOB emission limits. WSD to WSD coexistence issue could be managed by the industry to determine the best approach to avoid mutual interfere between WSDs.

47. **Summary of Responses:** The majority of the Respondents did not agree with the proposed OOB emission limit. The Respondents highlighted that the OOB value would remain the biggest impediment to realising the full potential performance of TVWS as the limit was overly strict and it would be costly to manufacture such devices. One Respondent however commented that OOB emissions should be more stringent to prevent WSDs from causing interference to their existing services.

48. **IDA's Views and Decision:** IDA notes the industry's concerns on establishing an OOB emission limit that is overly stringent. However, IDA also notes that the -56.8dBm limit⁹ has been set by the FCC, and IDA understands that there are already commercially available FCC-certified WSDs that are able to meet this requirement. In addition, IDA is of the view that as a prudent measure, strict OOB emission limits should be imposed during the initial deployment of TVWS technology to ensure that there will not be any adjacent channel interference to local broadcast services. IDA will monitor the TVWS deployment in Singapore, and will review the OOB emission requirements and rules of operations for WSDs in adjacent channels, if the experience

⁹ Emission measurements in the adjacent channels should be performed using a minimum resolution bandwidth of 100kHz with an average detector.

reveals that these could be further relaxed without causing harmful interference to local broadcast services.

Coexistence of WSD with Other Protected Services

(i) Co-channel Operation – Coexistence Measures

49. **Background:** In order to ensure coexistence between WSDs and other protected services¹⁰ within the TVWS channels, IDA had proposed the necessary coexistence measures and required these services to be registered in the Geo-location Database. It was envisaged that with the location information provided by the WSD, the Geo-location Database would compute the TVWS channels available at its location and the permissible maximum transmission power for each channel. The computation would be based on propagation modelling, WSD location and noise floor levels in Singapore¹¹.

50. **Summary of Responses:** The Respondents were largely agreeable to the coexistence approach that was proposed by IDA. The Respondents were of the view that the Geo-location Database algorithm could determine the channel availability and maximum transmission power limit when queried by the WSDs. Some Respondents indicated that spectrum efficiency could be improved by allowing spectrum sensing as a complementary measure. The Respondents also highlighted that since the bandwidth for these protected services would be smaller, they should occupy the same channel so as to optimise spectrum usage. There should also be a cap to the number of channels that could be used for such protected services in order to encourage better optimised use of the spectrum.

51. **IDA's Views and Decision:** To optimise spectrum usage, IDA agrees that protected services with narrow-band operations could coexist in a single UHF channel. This will be the approach going forward for any new frequency application for protected services that needs to operate in the TVWS channels. However, since there are existing systems of protected services that are already operating in the TVWS channels, IDA will have to implement measures to ensure coexistence between WSD and these secondary users.

52. The coexistence measures and Geo-location Database algorithm to determine channel availability and maximum transmission power limit are summarised as follows:

- a) The Geo-location Database will determine the separation distance between the WSD and the receiver station of the protected services. Following that, the Geo-location Database will calculate the path loss using IDA's prescribed propagation model (see Paragraphs 53 to 55 of this document).
- b) To avoid any interference issues, a WSD signal propagation reaching the receiver station of the protected services will be at the noise floor level of -115dBm. On this basis, the Geo-location Database will compute the

¹⁰ Generally, these protected services in the VHF/UHF band are the TV broadcasting services, Private Mobile Radio and wireless microphones services. IDA may include other services in the future.

¹¹ Measurements taken at four locations in Singapore indicated that the average noise floor level in Singapore would be between -110dBm to -115dBm.

maximum transmission power level for the WSD for each available TVWS channel.

(ii) Co-channel Operation – Appropriate Propagation Model

53. **Background:** Three propagation modelling methodologies were considered for the Geo-location Database computation, these were the: Free Space Path Loss Model (“**FSL**”), Hata Okumura Path Loss Model (“**Hata**”), and Longley Rice Path Loss Model (“**Longley Rice**”). It was assessed that the Hata model would be more appropriate for Singapore’s environment, since this model was well accepted for modelling the signal propagation in urban areas and widely used by commercial or research institutions.

54. **Summary of Responses:** Some Respondents supported the proposal and generally agreed that the Hata-Urban and Suburban model would be most practical. However, some respondents had doubts about the Hata-Urban model being suitable for Singapore and had suggested using the Longley Rice and ITU-R P.1411-6 models instead.

55. **IDA’s Views and Decision:** As highlighted by some of the Respondents, the proposed Hata model is the most practical model to adopt and the easiest to implement to facilitate the earlier stages of TVWS deployment. IDA recognises that the Hata model does not take into consideration terrain data and may not be applicable for computation of less than 1km. However, the alternative propagation models proposed by the Respondents may create unnecessary complexity for the initial deployment of TVWS and increase Geo-location Database cost. To facilitate roll out of TVWS services, IDA believes that the key is to identify a propagation model that will sufficiently address coexistence issues with the protected services, and currently the Hata model is assessed as being best able to meet this requirement. However, IDA may require the Geo-location Database providers to consider incorporating more complex propagation models over time as the TVWS technology matures.

Management of Licence-Exempt Wireless Microphones

(i) Safe Harbour Channels

56. **Background:** Today, wireless microphones may operate on a licence-exempt and unprotected basis so long as they comply with IDA’s Short Range Device (“**SRD**”) Technical Specification. Although from a regulatory perspective, both licence-exempt wireless microphones and WSDs should not be offered protection from each other’s operations, it is still important to ensure that both services are able to coexist. IDA had thus proposed, in the Consultation, to allocate safe harbour channels for licence-exempt wireless microphone usage, where WSDs would not be allowed to operate in these channels. As for wireless microphone operations that are approved by IDA, such as for the National Day Parade and Formula-1, IDA had proposed that these operations be protected using the methodology defined in Paragraph 52 of this document.

57. **Summary of Responses:** The Respondents were divided on this issue. One held the view that safe harbour channel would not be entirely useful, as wireless microphones used a wide range of frequencies, and it would be difficult to ensure that

these microphones operate only within the safe harbour channels. Also, this would reduce the number of channels available to WSD. The other group was of the view that the proposed two safe harbour channels would not be sufficient.

58. IDA's Views and Decision: IDA has considered the views from the Respondents and understands that it is necessary to strike a balance between the needs of wireless microphones (including wireless in-ear monitor) and WSDs. It should be noted that as the operations of both licence-exempt wireless microphones and WSDs will be on a shared-use, unprotected and non-interference basis, IDA is under no obligation to protect one operation from the other. However, as some WSDs will be allowed to operate at higher transmission power as compared to wireless microphones, it would be reasonable to provide some degree of certainty on spectrum availability to wireless microphones users. Moreover, existing wireless microphones do not have the necessary capabilities to function as a WSD¹² and may experience radio frequency interference when operating near any high power WSDs.

59. Typically, the operating bandwidth of wireless microphones (both analogue and digital) is 200 kHz. With a frequency separation of approximately 400 kHz or more required between two wireless microphones operating in parallel, one 8 MHz safe harbour channel is able to accommodate up to 10 wireless microphones in one single location. In view of the above, IDA will set aside two safe harbour channels for wireless microphones that are protected from WSDs. This will address the typical needs of wireless microphones while not causing excessive reduction in the number of channels available for WSDs. Licence-exempt wireless microphones users are advised to operate within the two safe harbour channels and the operations are required to comply with the SRD Technical Specification. Licence-exempt wireless microphones that choose to operate outside the two safe harbour channels in the remaining channels in the TV VHF/UHF band will be unprotected from interference.

60. IDA is aware that for the operation of wireless microphone and wireless in-ear monitor in the same location, an 8 MHz channel separation would be required; therefore the two safe harbour channels should not be contiguous. The two designated safe harbour channels will be Channel 25 (502 – 510 MHz) and Channel 47 (678 – 686 MHz).

(ii) Licence-Exempt Wireless Microphones for Ad Hoc Events

61. Background: In addition to the safe harbour channels, IDA had sought views on the need to develop a process to accommodate wireless microphone users who might need more than the allocated safe harbour channels for their events. This would be similar to the process adopted by the FCC, where users would have to register with IDA to request for additional channels for operation with appropriate justifications, and upon approval these users would have to register their wireless microphone operations with an authorised TVWS Geo-location Database for protection.

62. Summary of Responses: Most Respondents agreed that such a registration process should be developed to support coexistence between WSDs and wireless

¹² Existing wireless microphones do not have in-built spectrum sensing capability or the ability to query the Geo-location Database for available channel of operations. As such, they do not have the interference avoidance mechanism that is part of a WSD functionality.

microphones. However, the Respondents differed on the level of protection to be provided for wireless microphones. One group was of the view that it would be sufficient to implement only the registration process for wireless microphones and there would be no need for the safe harbour channels in order to optimise the use of TVWS spectrum. The broadcasting community indicated that there would be some wireless microphone operations that would be unplanned to cover breaking news, and had requested for IDA to designate UHF channels exclusively for electronic news gathering.

63. **IDA's Views and Decision:** IDA understands that there may be a number of events (including those middle-scale events such as outdoor concerts, outdoor broadcast productions, etc.) where the requirement for licence-exempt wireless microphones could not be fulfilled by the two safe harbour channels. The requirement for additional channels would need to be achieved using the non-safe harbour channels in the TV VHF/UHF band. However, bearing in mind the nature of such live show events (where spectrum usage is usually localised and temporary for a few days), it is reasonable to provide protection from WSDs to ensure minimal disruption to the operation of such wireless microphones at these events.

64. IDA is of the view that under such circumstances, wireless microphone users should be allowed to request for more channels via a registration process. The registration process will include seeking IDA's prior approval with the necessary justifications before registering the wireless microphone operations with an authorised Geo-location Database for protection¹³. It should be noted that the protection of these additional channel(s) from WSDs is temporary and is valid only at the approved location and during the stipulated period. The details of the registration process for these additional channels will be released at a later date.

Cross-border Coexistence

65. **Background:** In IDA's proof-of-concept trials, a 7km exclusion zone was implemented in the northern borders of Singapore and within this area, WSDs were not allowed to operate in specific TVWS channels. However, recognising that this might not be the most flexible or optimal approach, and IDA had proposed to refine it further by allowing varied power levels for WSDs. To implement this, IDA would demarcate a borderline and WSDs signal propagation level reaching this borderline should not be higher than -120dBm. This demarcated borderline was to indicate the area in which WSD signal emission would be contained, and to ensure that the signals received in the neighbouring country would be below the noise floor level.

66. **Summary of Responses:** Most Respondents were supportive of the idea and agreed that this would be a straightforward way to manage the cross border interference problem. However, there was a general view that the arrangement could be further improved by incorporating details of TV broadcast towers and receivers

¹³ At the outset, IDA will manage the protection of these wireless microphones, as part of the protected services, using the measures as set out in Paragraphs 49 to 52, i.e. wireless microphone users will not be required to register the wireless microphone operation with an authorised Geo-location Database directly as IDA will perform the registration. However, IDA may in the future revise the process such that individual wireless microphone users are to register directly with an authorised database provider after seeking IDA's prior approval for additional channel(s) outside the two safe harbour channels.

situated in the neighbouring countries into the national Geo-location Database of services that would require protection from WSD. Some Respondents had requested IDA to relax the borderline level of -120dBm as this limit would be overly stringent.

67. **IDA's Views and Decision:** IDA agrees with the Respondents that having more information on the neighbouring countries' broadcast transmitters and receivers will increase the accuracy and allow for better cross border coexistence. However, as the neighbouring countries are in the process of transiting from analogue to digital television services, and new transmitters and receivers are still being deployed, in the near-term it may not be possible to incorporate such information into the Geo-location Database. Also, including such information may require extensive cross border coordination and agreement between the regulators and operators.

68. With regard to relaxing the -120dBm limit, IDA has extended radio monitoring scans to border areas and established that the noise floor levels at these areas are approximately -115dBm. As such, it is possible to relax the limit for signals propagated by WSDs to the borders of Singapore to -115dBm.

Aggregation Effects

69. **Background:** Studies have been carried out to investigate the aggregation effect of multiple WSDs operating in a specific location¹⁴. The conclusion was that the aggregation effect would not be significant and regulators might not need to recommend a limit on the number of WSDs that could operate at any one location. As such, in the Consultation, IDA had proposed that adjustment to the separation distances might not be necessary and the number of WSDs operating at one location would not affect the defined protection criteria.

70. **Summary of Responses:** Most Respondents were supportive of the proposal, and agreed that there was no need to impose any limit on the number of WSDs at any one location. However, some Respondents were not supportive of the idea and believed that un-coordinated WSDs operating in the same geographical area on co-channels would cause interference to build up and limit the performance of WSDs and spectrum efficiency.

71. **IDA's Views and Decision:** IDA notes that both the FCC and OFCOM have not proposed to regulate the aggregation interference effect on protected services, when multiple WSDs operate in a single location. Studies conducted by OFCOM concluded that such aggregation of interference would unlikely be problematic in the short term. IDA believes that the same conclusion can be applied to the Singapore's context as well. Furthermore, for WSDs to coexist, many will implement "polite" protocols, such as listen-before-talk collision avoidance used in Wi-Fi, or "frequency hopping" used in Bluetooth. In such cases, it is unlikely that WSDs will transmit at the same time and at the same frequencies when in close proximity. As such, IDA will not limit the number of WSDs operating at any one location.

¹⁴ <http://stakeholders.ofcom.org.uk/binaries/consultations/white-space-coexistence/annexes/technical-report.pdf>

Location Determination and Accuracy

72. **Background:** The location of WSD must be provided with a high degree of accuracy in order for the Geo-location Database to calculate the available spectrum in a given location. Three geo-location technologies were assessed by IDA based on their degree of accuracy, cost-effectiveness and reliability. These technologies were Global Positioning System (“**GPS**”), cellular base-station triangulation and Wi-Fi. IDA had recommended the use of GPS as the most suitable method in determining a WSD location and to have the degree of accuracy of 50 metres or less.

73. **Summary of Responses:** In total nine Respondents supported the proposed level of accuracy as they considered the proposed 50 metres to be reasonable for the Singapore environment. However, some held the view that GPS should not be mandated as the geo-location technique as there were many other forms of geo-location techniques and it should be a matter left to the industry to decide. While other Respondents highlighted that the 50m location accuracy limit would be too restrictive and requested that IDA consider relaxing this value.

74. **IDA’s Views and Decision:** IDA recognises that there are several geo-location technologies that could be used by WSDs to determine their location and that each technology has its own limitations. IDA agrees with the Respondents that the decision on which localisation techniques to adopt should be left to the industry to determine. However, the industry will have to comply with the location accuracy requirements set by IDA. On the concern about whether the 50 metres restriction is too strict, IDA’s view is that since most WSDs are currently manufactured according to FCC’s specification, it will be practical to align the accuracy requirement with that of the FCC, i.e. of $\pm 50\text{m}$ location accuracy.

Manual Entry of Fixed WSD Coordinates

75. **Background:** For all Mode II and Fixed WSDs, once its location cannot be established, the WSD will not be able to commence operation, or it will have to cease its operations once its channel validity has expired. IDA recognises that the GPS will not be able to determine the location accuracy of indoor WSDs, and it may affect indoor operations of WSDs. To overcome this obstacle, IDA proposed in the Consultation that the location of Fixed WSDs could be determined by either an incorporated geo-location capability or a professional installer¹⁵. These installers would have to be responsible for determining the location of, and entering and storing accurate location information into the Fixed WSDs. To ensure that these installers would be qualified, IDA had proposed that such installers had to be approved and licensed by IDA.

76. **Summary of Responses:** Most Respondents supported the proposal to allow the manual entering and storing of geographical coordinates of indoor Fixed WSDs through a licensed installer that would be approved by IDA. There were further suggestions to extend to other classes of WSDs such as the outdoor Fixed WSDs and indoor Mode II WSDs with fixed location (nomadic).

¹⁵ The geographical coordinates of a Fixed Device could be determined by the installer at the time of installation or whenever the device is moved to a new location.

77. **IDA's Views and Decision:** It would be a challenge for any geo-location technology to determine the geographical location of a Fixed WSD that is located indoors. While IDA had proposed for a professional installer, licensed by IDA, to determine and store accurate geographic location into the Fixed WSD, IDA recognises that this may create additional administrative cost to companies that are interested in deploying TVWS infrastructure. As such, IDA will still allow the manual entry of geographical coordinates for Fixed WSDs, but the network operators or service providers using such WSDs shall be responsible for ensuring the accuracy of the geographic coordinates. When necessary, the network operators or service providers using such WSDs may employ professional installers to assist them with such specification work. IDA will take necessary enforcement and remedial measures if complaints are received on "rouge" Fixed WSDs or errors made during the manual installation that result in interference issues.

78. For Fixed WSDs, there will be minimal changes to the geographical location information after installation and also assessed to be of lesser risk of interference. Therefore, IDA is agreeable with the Respondents' suggestion to extend the above approach beyond indoor operation. IDA will permit the manual entry of geographical coordinates for Fixed WSDs operating in both indoor and outdoor environment. It is important to note that Fixed WSDs that have their geographic location manually entered would still have to adhere to the location accuracy of $\pm 50\text{m}$ that IDA has defined (see Paragraph 74 of this document) and this would apply to both indoor and outdoor environment.

TVWS Network and Application Type

79. **Background:** In developing the TVWS regulatory framework, IDA intends to adopt an application and service-neutral approach. To develop a greater understanding of the possible TVWS network topologies, IDA sought feedback from the industry on the possible scenarios for TVWS deployment. With these insights, IDA would be able to develop a framework that would not restrict or limit any type of TVWS network topology and implementation.

80. **Summary of Responses:** The Respondents highlighted the importance of having a regulatory framework that would not restrict any future development and advancement of TVWS network topologies. However, some Respondents had cautioned against allowing chain forming, where client WSDs would be able to become master WSDs for other units. Some Respondents also requested for clarification on whether indirect Geo-location Database access would be allowed, i.e., where a WSD could access the Geo-location Database indirectly through another WSD(s) that could be equipped with the ability to query Geo-location Database.

81. Some of the key topologies and applications that the industry were interested in using for TVWS network deployments were: (i) Fixed WSD network for sensor or utility networks with stationary sensors and meters; (ii) Master and Client Network for Internet broadband networks with user terminals such as laptops or smartphones; (iii) Point-to-point communications to provide backhaul transmission; (iv) Point-to-multipoint communications for rural wireless broadband; (v) M2M communications; (vi) small cells wireless backhaul transmission; and (vii) broadcast communication for content distribution applications.

82. **IDA's Views and Decision:** IDA recognises that there is a wide range of network topologies and use cases available for TVWS. In order to encourage innovation, the TVWS network topologies will not be regulated. However, the operation of WSDs within a TVWS network will have to adhere to the technical parameters and operational guidelines that are defined by IDA within the regulatory framework.

83. To mitigate the chain forming issue, IDA will require the master WSD of each network to obtain channel availability information of its location from the Geo-location Database and not use channel availability information of other WSDs. This will prevent master WSDs from operating on channels that may not be available at its operating location. With regard to indirect Geo-location Database access issue, IDA will allow only Fixed WSDs to operate in such a manner. A Fixed WSD could indirectly access the Geo-location Database through another Fixed WSD to register and obtain information on channel availability and transmission power level at its location. The network operator or service provider using WSDs that are indirectly accessing the database, will be responsible in ensuring that there will not be any interference caused.

Management of the Geo-location Database

(i) Geo-location Database Development and Management

84. **Background:** The Geo-location Database is one of the critical components for TVWS operation in Singapore. Majority of the Respondents to the Consultation agreed with IDA's proposal to implement a Geo-location Database to manage the coexistence between WSDs and the protected services (see Paragraphs 15 to 18 of this document). Notwithstanding the regulatory guidelines that IDA will define for the Geo-location Database operation, an important factor for consideration is the entity that will develop and manage the Geo-location Databases for Singapore. In the Consultation, IDA proposed two possible approaches that could be adopted for the provisioning of a national Geo-location Database, which were: (i) an industry-managed approach, which would allow multiple industry players to develop and maintain their respective Geo--location Databases; and (ii) a government-managed approach, whereby IDA would develop and manage the Geo-location Database.

85. **Summary of Responses:** An overwhelming majority of the Respondents had indicated that the Geo-location Database should be industry-managed and the government should step in only when there was no industry interest. There were several Respondents who believed that a government-managed Geo-location Database would be preferable, due to concerns such as business confidentiality, potential preferential treatment to any user, or the lack of interest/expertise from the industry.

86. **IDA's Views and Decision:** Given the strong industry interest to manage the Geo-location Database, and its capability to do so, IDA agrees that it is preferable for the industry to manage the Geo-location Database. Besides providing basic Geo-location Database services, there are ongoing industry efforts to develop and offer additional value-added service that would include the provision of information on TVWS channel "cleanliness", and also managing the coexistence issues between WSDs. As such, IDA believes that an industry-managed Geo-location Database

approach will allow further innovation of the Geo-location Databases and in turn bring greater benefits to the TVWS ecosystem as a whole.

87. IDA noted the Respondents' concerns about data protection and anti-competitive behaviours if an industry-managed approach is taken. IDA believes that these issues will be adequately addressed through the Personal Data Protection Act and IDA's licensing and regulatory frameworks¹⁶. In adopting an industry-managed approach for the database, it is of key importance that IDA maintains greater regulatory over-sight of the Geo-location Database operations. The database provider will be required to comply with IDA's regulatory framework, technical specifications and take responsibility for the security and operation of the Geo-location Database.

88. Thus, companies that are interested in developing and managing a Geo-location Database service in Singapore will be required to apply for a Services-based Operation ("**SBO**") (Individual) licence. The duration of the licence will be for a period of 5 years¹⁷, and the licensee shall pay to IDA the annual licence fees for the provision of the Geo-location Database services, in accordance with the current SBO licence fee framework¹⁸.

89. However, given that TVWS technology adoption is still at its infancy stage in Singapore, IDA will waive the annual SBO licence fee for the Geo-location Database providers in the first two years of implementation. IDA expects these providers to take the initial years to co-ordinate the technical parameters amongst themselves and with IDA to ensure smooth functioning of the databases. Subsequently, IDA will assess whether to continue the waiver of the licence fee. As a start, IDA will not restrict the number of database providers operating in Singapore.

(ii) Business Models of Geo-location Database Services

90. **Background:** IDA had invited companies to register their interest in developing and managing a national Geo-location Database. To better assess the sustainability of a Geo-location Database provider in Singapore's market, IDA had requested for interested Geo-location Database providers to provide information on (i) funding for Geo-location Database development and management; (ii) business models; and (iii) cost to TVWS users.

91. **Summary of Responses:** The responses received from the public consultation indicated that there would be a few Geo-location Database providers that would be interested in developing the Singapore Geo-location Database, with only one company indicating that government funding might be required. These Respondents highlighted that since TVWS is still at a nascent stage of development, the business models and plans would be in the experimental and developmental phase. One possible business model would be a partnership-based arrangement between the Geo-location Database providers and WSD manufacturers, where the manufacturers

¹⁶ Geo-location Database providers will have to abide by the Telecom Competition Code and the SBO licensing conditions.

¹⁷ This term can be renewed at IDA's discretion.

¹⁸ The licence fee is as follows: (i) A minimum sum of \$4000; (ii) 0.5% of such amount of the Licensee's audited AGTO for the provision of the services during the Licensee's financial year that is more than \$50 million up to \$100 million; and (iii) 0.8% of such amount of the Licensee's audited AGTO for the provision of the services during the Licensee's financial year that is more than \$100 million.

would pay the Geo-location Database providers for the provision of Geo-location Database services. The fees associated with on-going basic support for WSDs would be commercially negotiated between the manufacturers and the Geo-location Database providers. Revenue could also be generated by levying additional charges for value-added services¹⁹ offered to WSD manufacturers and network operators that would extend beyond the basic service and regulatory requirements.

92. **IDA's Views and Decision:** The business model as shared by some Geo-location Database providers indicates that revenues could be generated through optional value-added services provided to network operators and partnership with WSD manufacturers. In addition, the provision and management of HPCs (see Paragraphs 25 to 30 of this document) could be another source of revenue for the Geo-location Database providers.

93. With regard to investment funding, IDA understands that most of the investment would be made in the development of the core platform and once the Geo-location Database has been developed, the ongoing costs to maintain the Geo-location Database will not be significant.

(iii) **Conditions for the Operation and Administration of the Geo-location Databases**

94. **Background:** IDA had proposed to adopt an industry-driven approach and had spelt out several preliminary conditions for the operation and administration of the Geo-location Databases. These proposed conditions were recommended to address potential anti-competitive behaviours, ensure conformance to technical specifications and clarify the procedures for data/server management.

95. **Summary of Responses:** Eight of the Respondents who commented on the proposals agreed with the proposed conditions to safeguard the interests of TVWS operation in Singapore. However, they highlighted that the laws and regulations should not be overly burdensome such that they would stifle the development and deployment of TVWS services.

96. **IDA's Views and Decision:** As IDA will be adopting an industry-managed approach for the Geo-location Database, it would be important for potential Geo-location Database providers to have a good financial standing and the necessary expertise and experience in commercial database deployment in other countries.

97. As explained in Paragraphs 84 to 89 of this document, IDA intends to license Geo-location Database providers to ensure adherence to IDA's regulatory frameworks and technical requirements. The proposed licence conditions for the provision of Geo-location Database service is set out in **Annex A**²⁰. Through such a licence, IDA will be able to take the necessary enforcement or remedial actions if the Geo-location Database providers are unable to meet the defined operating conditions.

¹⁹ These value added services could include providing information on cleaner TVWS channels and offering priority access to TVWS spectrum.

²⁰ The licence terms and conditions highlighted in **Annex A** are indicative and may be subject to further changes.

Geo-location Database Operations

98. **Background:** The interaction between WSDs and an authorised Geo-location Database was defined in the public consultation paper. In general, the sequence of operations would be as follows (i) a Fixed/Mode II WSD would consult a website containing a list of IDA authorised Geo-location Databases and select its preferred Geo-location Database; (ii) the Fixed/Mode II WSD would query its selected Geo-location Database and receive the channel availability and permissible maximum transmission power level information; and (iii) if the Fixed/Mode II WSD is part of a network, then it would send control signals to other WSDs on the available TVWS channels.

99. **Summary of Responses:** In general, the Respondents were supportive of the proposed sequence of operation as it was consistent with the OFCOM model and was supported by the IETF PAWS draft standards. Some Respondents had also proposed that IDA's Telecommunications Standards Advisory Committee ("**TSAC**") Working Group 6 assess and recommend the standardisation aspect of the protocol and interfaces.

100. **IDA's Views and Decision:** It was initially proposed that, before a WSD query a Geo-location Database, it would first have to access the IDA website to obtain a list of authorised Geo-location Databases. This is to prevent any WSD from querying an unauthorised Geo-location Database. However, IDA notes that firstly, most commercially available WSDs are based on FCC's specification which does not require a WSD to access a website containing a list of authorised Geo-location Databases. For Singapore to proceed with such an approach, this will require modification to these WSDs. Secondly, with the proliferation of WSDs for M2M communication or wireless broadband access, it is envisaged that a large number of WSDs will access the website. This website could potentially become a bottleneck for WSD operations. In view of these considerations, to minimise WSD modification and risk of a single point of failure, IDA believes that it may be more feasible for the industry (i.e., Geo-location Database providers and equipment manufacturers) to establish the appropriate authentication procedures that would assure WSDs that the information received is from an authorised source. As such, the sequence of operation will be modified from the proposed arrangement in the Consultation, where Fixed/Mode II WSD will directly query its preferred Geo-location Database instead of via an IDA website containing the list of authorised Geo-location Databases. This revised sequence of operation between a WSD and the Geo-location Database is highlighted in **Annex B**.

101. For the communication protocols between the WSDs and the Geo-location Database, IDA will align with international standards or emerging IETF PAWS or IEEE standards to ensure compatibility and economies of scale in manufacturing the devices and equipment. There will not be a mandated set of standards, but rather, IDA will recommend or endorse appropriate standards for adoption, and this will be managed by IDA's TSAC Working Group.

Frequency of Geo-location Database Updates & WSD Queries

(i) Frequency of Update for Time Validities

102. **Background:** The time validities define the frequency in which (i) the Geo-location Database will have to query IDA's service list for updated information on protected services (Time Validity A); and (ii) the WSD will have to re-query the Geo-location Database when the channel validity expires (Time Validity B). Based on the dynamism of the white space spectrum and the small geographical size of Singapore, IDA indicated in the Consultation that it was of the view that a time validity of 6 hours for each process would be appropriate (see **Annex B** for reference).

103. **Summary of Responses:** In general, the Respondents are supportive of the proposed Time Validity A, however some Respondents suggested decreasing Time Validity B in order to achieve more efficient use of the TVWS spectrum. There were also proposals that included requiring the Geo-location Database to inform a WSD of the channel status actively (i.e. pushing of channel availability information).

104. **IDA's Views and Decision:** IDA notes the proposal by Respondents to shorten Time Validity B to maximise the use of TVWS spectrum because a WSD may not fully utilise its TVWS channel for the full 6 hour period. IDA has considered this proposal but notes that to shorten Time Validity B permanently, it will increase the load of the Geo-location Database as a WSD will have to query it more frequently. There is thus a trade-off. IDA is of the view that during the initial phase of TVWS deployment, it is unlikely that there will be a lack of TVWS spectrum, and as such, it is possible to maintain both Time Validities at 6 hours each. As for the proposal for the Geo-location Database to proactively push channel availability information to the WSDs, IDA is of the view that this need not be mandated, but can be left to the Geo-location Database providers to decide. Most commercially deployed Geo-location Database does not have this function.

(ii) Configurable Time Validities

105. **Background:** IDA had proposed to include a parameter within the authorised Geo-location Database and WSD that would allow adjustment of the value of both time validity factors according to the operational circumstances. Thus, Geo-location Database providers would require clarity of the time range to cater for servers' resources and processes. IDA had proposed that the time range of Time Validity A and B should be between 6 to 12 hours (i.e. summation of both time validity factors to be within this range).

106. **Summary of Responses:** Most Respondents that supported the proposal were of the view that dynamic adjustment to the parameter on time validity would allow better spectrum management in the future. Their feedback was that there should be clarity on the time range so that WSDs could be designed accordingly. The information on time validity could be refreshed through the Geo-location Databases or IDA website. Other Respondents suggested that IDA should not regulate Time Validity B; instead it should be determined by the Geo-location Database based on empirical experience.

107. **IDA's Views and Decision:** In anticipation of future and developing needs, IDA is of the view that both time validities should be configurable. With increasing adoption of TVWS technology over time, there will be a need to ensure efficient allocation of TVWS channels and in turn a shorter validity period to prevent hogging of a TVWS channel for a 6-hour period. IDA has been informed by the Geo-location Database providers that there will not be any issue incorporating such a capability into the Geo-location Database. As such, as a start, IDA will adopt the time range that was proposed in the Consultation, which is between 6 to 12 hours.

Registration of WSD Operational Parameters in the Geo-location Database

108. **Background:** In the consultation, IDA noted the benefits of having the TVWS Geo-location Database maintain a record of the actual operational information of the WSDs. Under this approach, the WSDs would report its selected channel for use and its transmission power back to the Geo-location Database. This would allow any interfering WSD to be easily identified and also provide clarity on the utilisation of TVWS at specific locations. This approach would be similar to that adopted by OFCOM²¹. However, to implement such an approach, additional resources might be required from the Geo-location Database providers to process and store the operational information of every WSD. IDA had solicited feedback from the industry to weigh the benefits and trade-offs.

109. **Summary of Responses:** Most Respondents were supportive of this approach and believed that the operational parameters might provide some valuable information. However, some Respondents assessed that the overhead cost would be high.

110. **IDA's Views and Decision:** IDA noted the industry feedback that while it is beneficial to collect more information on the operations and usage pattern of the WSDs (i.e. TVWS channel used and operating power level), IDA agrees that the trade-offs will have to be considered carefully. In the future when there is extensive use of WSDs, it will increase the load on the Geo-location Databases in terms of the processing and storage required, in order to accommodate this information. In a multiple player, industry-managed Geo-location Database approach, synchronisation of this information will better help optimise spectrum utilisation, but this will in turn cause increased overhead for Geo-location Database synchronisation. In addition, certain system may be designed to operate with fast changing operational parameters, such as the frequency hopping system. In such cases, reporting of operational parameters may not be easy and will create significant overhead to the overall system.

111. In view of the above, IDA will not require the WSDs to report back its operational parameters to the Geo-location Database providers; instead this will be included as an optional feature in the Geo-location Database operations and information storage.

²¹ <http://stakeholders.ofcom.org.uk/consultations/whitespaces/>

Registration of TVWS User Contact Information in the Geo-location Database

112. **Background:** In the Consultation, IDA proposed to require all WSDs querying the Geo-location Database to register its Unique WSD Identifier and operating location with the Geo-location Database. However, as Fixed WSDs could operate at a higher power beyond 100mW EIRP, up to 4W EIRP, IDA had indicated that it would be necessary for such WSDs to register with the Geo-location Database and provide comprehensive contact information. Should any interference issue related to these Fixed WSDs arise, IDA would then be able to contact the user or operator of the system and require them to take the necessary corrective actions.

113. **Summary of Responses:** Most Respondents were supportive of the proposal and agreed that the registration of contact information with the Geo-location Database would be useful as it would help IDA to manage and troubleshoot interference issues expeditiously and effectively. One Respondent highlighted that although other regulators had not mandated a requirement for low power WSDs (100mW EIRP) to register with the Geo-location Database providers, such an approach could be useful and could be feasibly supported by the Geo-location Database providers. In addition, the Respondents also proposed that IDA provide more clarity on how these contact information would be managed and treated, to address concerns on personal data protection.

114. **IDA's Views and Decision:** Considering that Fixed WSDs can operate at a maximum power level of up to 4W EIRP, it is important for IDA to have access to the TVWS user contact information. This will allow IDA to take action to resolve interference issues expeditiously.

115. Management of any personal data by Geo-location Database providers will have to be in accordance with Singapore's Personal Data Protection Act.

116. As for low power WSD (i.e. Mode I and Mode II WSDs), it is expected that the use of these WSDs will become prevalent when TVWS chipset are built into consumer devices (e.g. smart phones, tablets, etc) for Wi-Fi application. It will be too resource intensive for the Geo-location Database to keep track of information from these mobile devices. Since Mode I and Mode II WSD are operating at low power (i.e. 100mW), there will be lower risk of causing interference issues, thus storing the location and Unique Device ID information will be sufficient.

PART III: FINALISED REGULATORY FRAMEWORK FOR TV WHITE SPACE OPERATIONS

117. Based on the responses from the public consultation, IDA has fine-tuned the TVWS regulatory framework to incorporate recommendations from the industry. The following summarises IDA's decision on the various key issues and also the way forward.

Licensing Framework for WSD

118. WSD operations will be on a licence-exempt basis. However, its technical and operational parameters will be subject to the technical specifications as defined by IDA.

119. To give effect to the opening up of the TVWS channels for the operation of WSD on a licence-exempt basis, IDA will be amending the Telecommunications (Exemption From Section 33, 34(1)(b) and 35) Notification.

120. WSD equipment will be required to register under the GER scheme.

121. Subject to administrative and gazetting process, the above amendments for publication in the *Government Gazette* are expected to take effect by **1 November 2014**. IDA may postpone the effective date if industry needs more time to prepare for commercial operation. IDA will inform the industry in advance should there be a change in the effective date.

Frequencies for TVWS operations

(i) Common TVWS Frequencies

122. The following channels highlighted in Table 2 are available for TVWS operations, subject to IDA's requirements and regulations. Please note that when ASO occurs, there will be further amendments to the available TVWS channels. The 700MHz band (694 – 806MHz) will be allocated for IMT services and will no longer be available for TVWS operations. Prior to the allocation for IMT services, IDA will remove 14 channels (Channel 49 – 62) from TVWS usage and notify the industry accordingly.

Table 2: TVWS Channels of Operations

	<u>TVWS Channels</u>	<u>Total No. of Channels</u>	<u>Total Bandwidth</u>
VHF Band	i) 181 - 188MHz (Channel 6) ii) 209 - 223MHz (Channel 10 and 11)	3	21MHz
UHF Band	i) 502 – 518MHz (Channel 25 to 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

123. Channels 25 and 26 will be blocked from TVWS operations through the Geo-location Database until further field tests have been conducted on adjacent channel interference. Channels 25 and 47 will be utilised for safe harbour operations of licence-exempt wireless microphones operating in accordance to the IDA Short Range Device Technical Specification. Thus, Channel 47 will also be blocked from TVWS operations through the Geo-location Database.

(ii) High Priority Channels

124. Two channels will be designated as HPCs²². These channels can only be activated when there are no common TVWS channels available at a WSD location.

125. The HPC access will be managed by the Geo-location Database and the allocation method (including any fees to be imposed) will be left to the commercial decisions of the Geo-location Database providers. However, Geo-location Database providers will have to inform IDA of its intended HPC allocation method as part of the licensing process and the allocation method should be transparent.

126. Allocation and management of the HPCs will not be a mandatory requirement for Geo-location Database providers. Geo-location Database providers that choose not to include HPC allocation as part of their Geo-location Database service will have to block out these HPCs from their Geo-location Databases. While, interested Geo-location Database providers should synchronise the HPC usage amongst themselves to ensure the effective usage of HPCs.

WSD General Operating Parameters

(i) Categories of WSD

127. Three categories of WSD will be allowed in Singapore. These are summarised in Table 3 and the details are provided below:

Table 3: Categories of WSD

	Fixed WSD	Mode I WSD (Portable)	Mode II WSD (Portable)
Ability to Query the Geo-location Database	Yes	No	Yes
In-built Geo-location Capability	Optional	No	Yes
Maximum Power Level	4W EIRP	100mW EIRP	100mW EIRP
Tuneable Power Level	Optional	Optional	Optional

- a) Fixed WSD: Fixed WSDs shall transmit and receive at a specified fixed location. Such WSDs should have the ability to query the Geo-location Database and select a TVWS channel for operation based on the list of available TVWS channels provided by the Geo-location Database. A Fixed

²² It should be noted that HPCs availability is subject to the utilisation of these channels. For example, if a company uses HPCs at a specific location, then these channels will no longer be available to other companies at that location.

WSD shall have the ability to transmit at a power level capped at a maximum of 4W EIRP. Fixed WSDs are able to initiate a network by sending enabling signals to other client WSDs. IDA will require all TVWS networks to have at least one Fixed WSD or Mode II WSD (see below) at all times.

- b) Mode I WSD (Portable): Operation by the Mode I WSD will only be allowed with the presence of a Fixed WSD or Mode II WSD in the same TVWS network. Due to its mobility, IDA will require the transmission power of such WSDs to be capped at a maximum of 100mW EIRP. This mode of operation does not require the use of geo-location capabilities and will not require access to the Geo-location Database, but will determine its operating channel through a Fixed or Mode II WSD.
- c) Mode II WSD (Portable): Mode II WSDs will be required to have an in-built geo-location capability and the ability to query the Geo-location Database to select a TVWS channel for operation based on the list of available TVWS channels provided by the Geo-location Database. Due to its mobility, IDA will require the transmission power of such WSDs to be capped at a maximum of 100mW EIRP. IDA will require all TVWS networks to have at least one Fixed WSD or Mode II WSD at all times.

128. The transmission output power²³ 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.

(ii) Antenna Requirements

129. All transmit and receive antenna(s) of personal/portable WSDs shall be permanently attached. The height of the antenna is defined as the height above ground, which will enable a Geo-location Database to generate operational parameters based on the height of the WSD.

(iii) Out-of-Band (“OOB”) Emission

130. The OOB emission limits for WSDs operating in channels adjacent to local broadcast channel shall be -56.8dBm EIRP.

131. Emission measurements in the adjacent channels shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.

(iii) Unique WSD Identifier

132. Each WSD should have a unique identifier for tracking and verification purposes. The format for the identifier should be based on recognised standards (e.g. ETSI BRAN, TSAC Working Group) and international/industry practices (e.g. FCC

²³ 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.

defined identifier).The Geo-location Database will then be required to incorporate the flexibility to accept different types of Unique WSD Identifiers.

Geo-location Database Access Requirements

133. Prior to accessing the Geo-location Database, all WSDs will have to ensure that the Geo-location Database they are accessing is authorised by IDA. The list of authorised Geo-location Databases will be published on IDA's website when ready.

(i) Fixed WSDs

134. Prior to transmission, a Fixed WSD shall query a Geo-location Database to determine channel availability and transmission power levels at its fixed geographic location. This will be the primary approach for accessing the Geo-location Database. Operation of a Fixed WSD is only permitted on these available channels and power levels as indicated by the Geo-location Database, for a specified validity period. Additionally, a Fixed WSD that is equipped with spectrum sensing capability can also use spectrum sensing as a complementary method, so long as it does not cause interference issues to other devices and users.

135. The geographic coordinates of Fixed WSDs shall be determined to an accuracy of ± 50 m by either an incorporated geo-location capability or through a manual method of keying in the geographical coordinates.

136. A Fixed WSD may indirectly access an authorised Geo-location Database through another Fixed WSD. The Fixed WSD requiring indirect access to a Geo-location Database may transmit to another Fixed WSD on a channel which is indicated as available for use, to access the Geo-location Database to register its location and receive channel availability and transmission power level information. Subsequently, the newly registered Fixed WSD must only use the TVWS channels that the Geo-location Database indicates are available and transmit according to the maximum power level indicated by the Geo-location Database.

137. In the event where the Fixed WSD is unable to establish contact with an authorised Geo-location Database or when the authorised Geo-location Database becomes unavailable, the WSD must cease transmission. The Fixed WSD shall query the Geo-location Database for the channel availability and transmission power information in the three situations highlighted below. In these three situations, the Fixed WSDs will have to adjust its transmission parameters according to those provided by the Geo-location Database.

- a) Activation from a power-off condition;
- b) Change in its fixed location; and
- c) Expiration of channel validity period.

(ii) Mode II WSDs

138. Prior to transmission, a Mode II personal/portable WSD shall primarily rely on a Geo-location Database to determine channel availability and transmission power levels at its geographic location to an accuracy of ± 50 meters. Operations of a Mode II WSD is only permitted on these available channels and power levels as indicated by the Geo-location Database for a specified validity period and spectrum sensing can be

used as a complementary measure, so long as it does not cause interference issues to other devices and users.

139. In the event where the Mode II WSD is unable to establish contact with an authorised Geo-location Database or when the authorised Geo-location Database becomes unavailable, the WSD must cease transmission. The Mode II WSD shall query the Geo-location Database for the channel availability and transmission power information in the three situations highlighted below. In these three situations, the Mode II WSDs will have to adjust its transmission parameters according to those provided by the Geo-location Database.

- a) Activation from a power-off condition;
- b) Change of more than 100 meters from its original location; and
- c) Expiration of channel validity period.

140. A Mode II WSD may query the Geo-location Database for channel availability and transmission power information for multiple locations around or in the vicinity of its current location and use that information in its operation. A Mode II WSD may use such available channel information to define a geographic area within which it can operate on the same available channels at all locations. A Mode II WSD using such channel availability information for multiple locations must contact the Geo-location Database again if/when it moves beyond the boundary of the area where the channel availability data is valid, and must access the Geo-location Database daily even if it has not moved beyond that range to verify that the operating channel(s) continue to be available. Operation must cease immediately if the Geo-location Database indicates that the channel is no longer available.

(iii) Mode I WSDs

141. A Mode I personal/portable WSD need not query the Geo-location Database, however channel availability and transmission power information shall be obtained from a Master WSD, which could be either a Fixed or Mode II WSD with direct access to the Geo-location Database.

142. A Mode I WSD shall only transmit on receiving the transmission of a Master WSD. To initiate contact with a Master WSD, a Mode I WSD may transmit on a channel the Master WSD indicates as available for use by a Mode I WSD. Once the Mode I WSD receives contact verification signal from the Master WSD, it can commence transmission on channels that have been identified as available by the Master WSD. The Master WSD must provide the list of available channels to the Mode I WSD that is the same as the list of channels available to the Master WSD itself.

143. At least once every 60 seconds, except when the WSD is in power-off or sleep mode²⁴, a Mode I WSD must either receive a contact verification signal from the Mode II or Fixed WSD that provided its current list of available channels or contact a Mode II or Fixed WSD to re-verify/re-establish channel availability. A Mode I WSD must cease operation immediately if it does not receive a contact verification signal or is not able to re-establish a list of available channels through contact with a Fixed or Mode II WSD. Consequently, if a Fixed or Mode II WSD loses power and obtains new channel

²⁴ A mode in which the device is inactive but is not powered-down.

availability information, it must signal all Mode I WSDs it is serving to acquire and use a new channel list.

(iv) Channel Validity Period

144. At a minimum, WSDs shall query the Geo-location Database every 6 hours to obtain updated information of channel availability and transmission power level at its location. IDA will require this channel validity period of 6 hours to be configurable and the Geo-location Database should incorporate this flexibility for IDA to amend the channel validity period.

(v) Security Requirements for WSDs

145. Security measures shall be incorporated to ensure that communications between WSDs and authorised Geo-location Databases will not be corrupted and will prevent unauthorised interception/modification of data. Upon obtaining information from the Geo-location Database and selecting a channel for operation, the WSD shall adhere to the maximum power level as defined by the Geo-location Database for its selected channel of operation. Secure methods shall be employed to ensure that such transmission power information will not be manually modified.

146. The above security measures shall also be applicable for communications between Mode I portable WSDs and Master WSDs for purposes of providing a list of available channels. Contact verification signals transmitted from a Master or Mode I WSDs are to be encoded with encryption to secure the identity of the transmitting device.

(vi) Optional Requirements

147. WSD manufacturers and Geo-location Database providers may implement a system that pushes updated channel availability and transmission power information from the Geo-location Database to WSDs. However, the use of such a system is not mandatory, and the requirements for WSDs to validate the operating channel upon expiry of channel validity continue to apply if such a system is used.

Coexistence of Service

(i) Co-channel Coexistence

148. All WSDs must not cause interference to the protected services that are operating within the TVWS band, these include licensed wireless microphones and private mobile radio services. The Geo-location Database provider, through the Geo-location Database, shall be responsible for ensuring coexistence through the methodology prescribe below:

- a) The WSD will have to inform the Geo-location Database of its operating location and the height of its transmitting antenna. The Geo-location Database will determine the separation distance between the WSD and the receiver station of the protected services.
- b) The Geo-location Database upon receiving the location and height information will calculate the path loss using Hata propagation model between the WSD and the receiver station of the protected services. To

avoid any interference issues, the Geo-location Database will have to ensure the signal level propagated from a WSD reaching the receiver station will be at the noise floor level of -115dBm.

- c) On this basis, the Geo-location Database will use the path loss information to compute the maximum permissible transmission power level for the WSD for each available TVWS channel. The Geo-location Database will then return the spectrum availability information and the maximum transmission power for the respective channels to the WSD requesting this information.

(ii) Cross-border Coexistence

149. All WSDs must not cause interference to broadcasting and other services in the neighbouring countries. The Geo-location Database provider shall be responsible for ensuring cross-border coexistence through the methodology prescribe below²⁵:

- a) The WSD will have to inform the Geo-location Database of its operating location and the height of its transmitting antenna. The Geo-location Database will determine the separation distance between the WSD and borders of Singapore²⁶.
- b) The Geo-location Database upon receiving the location and height information will calculate the path loss using Hata propagation model between the WSD and the borders of Singapore. To avoid any interference issues, the Geo-location Database will have to ensure the signal level propagated from a WSD reaching the Singapore borders will be at the noise floor level of -115dBm.
- c) On this basis, the Geo-location Database will use the path loss information to compute the maximum permissible transmission power level for the WSD for each TVWS channel. The Geo-location Database will then return the spectrum availability information and the maximum transmission power for the respective channels to the WSD requesting this information.

(iii) Licence-Exempt Device Coexistence

150. The two designated safe harbour channels for licence-exempt wireless microphone operations are Channel 25 (502 – 510 MHz) and Channel 47 (678 – 686 MHz). In these safe harbour channels, there shall not be any TVWS operations.

151. In the event that users of licence-exempt wireless microphones require operations beyond the safe harbour channels, they shall seek approval from IDA with the necessary justifications. Subsequently, these users will need to register the approved wireless microphone operations with an authorised Geo-location Database for protection. The protection of these additional channel(s) is temporary and is valid only in the approved location and stipulated period.

²⁵ This methodology will only be needed for VHF channel 11, UHF channels 25, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, and 61

²⁶ The Malaysia and Singapore border is defined in the Agreement between the Government of Malaysia and the Government of the Republic of Singapore to delimit precisely the territorial waters boundary in accordance with the Straits Settlement and Johor Territorial Waters Agreement 1927, signed on 7 August 1995.

Geo-location Database Operations and Registration

(i) General Requirements

152. The Geo-location Database shall determine and provide to a WSD, upon request, the available channels and maximum transmission power level at the WSD's location. The available channels are determined based on the co-existence requirements in earlier sections.

(ii) Update of Licensed Service Information

153. At a minimum, authorised Geo-location Databases shall query the Geo-location Database every 6 hours to obtain updated information of licensed services that are to be protected. IDA will require this refresh period of 6 hours to be configurable and the Geo-location Database should incorporate this flexibility for IDA to amend the refresh period.

(iii) Security Requirements for Geo-location Database Operations

154. Geo-location Databases shall be protected from unauthorised data input or alteration of stored data. To provide this protection, TV Geo-location Database providers shall establish communications authentication procedures that allow the Fixed or Mode II WSDs to be assured that the data they receive is from an authorised source.

155. In making the lists of available channels to the WSDs, the Geo-location Database shall ensure that all communications between the Geo-location Database and the WSDs include adequate security measures such that unauthorised parties cannot access or alter the Geo-location Database or the list sent to the WSDs or otherwise affect the Geo-location Database system or WSDs.

(iv) Registration of WSDs

156. Fixed WSDs are required to register with the Geo-location Database when it is first activated or after changing location by providing the information listed below. The network operator or service provider responsible for a Fixed WSD must ensure that the Geo-location Database has the most up-to-date information for the Fixed WSD.

- a) Unique WSD Identifier
- b) WSD's geographic coordinates (latitude and longitude)
- c) Height of the WSD antenna
- d) Name of individual or business that is responsible for the WSD
- e) Name of a contact person responsible for the WSD's operation
- f) Address for the contact person
- g) Email address for the contact person
- h) Phone number for the contact person

157. A portable WSD operating in Mode II shall provide the Geo-location Database its unique identifier and the WSD's geographic coordinates (latitude and longitude accurate to ± 50 meters). The Geo-location Database shall have the mechanism to store the up-to-date information for Mode II WSDs for at least 6 months.

158. A portable WSD operating in Mode I shall provide the Geo-location Database its unique identifier through a Master WSD (i.e. either a Fixed or Mode II WSD). The Geo-location Database shall have the mechanism to store the unique identifier information of both the Mode I WSD and its Master WSDs for at least 6 months.

Licensing Framework for TVWS Geo-location Database Provider

159. Parties that are interested in developing and managing a TVWS Geo-location Database service in Singapore are invited to apply for an SBO (Individual) Licence from IDA.

160. With regard to licence fee, IDA will waive the annual SBO licence fee for the Geo-location Database providers in the first two years of implementation. Subsequently, IDA will assess whether to continue the waiver of the SBO licence fee.

161. There will be no limit set for the number of Geo-location Database providers to be licensed. However, in their application for the licences, IDA will require interested parties submit their vision for TVWS deployment in Singapore, and business plans, including plans on how they will ensure business continuity. More information of the SBO (Individual) Licence template can be found on the [IDA website](#) and the additional licence conditions²⁷ for a Geo-location Database provider are highlighted **Annex A**.

Effective Date of Regulatory Framework

162. The regulatory framework will take effect from **1 November 2014**. IDA may postpone the effective date if industry needs more time to prepare for commercial operation. IDA will inform the industry in advance should there be a change in the effective date.

²⁷ The licence conditions highlighted in Annex A are indicative and may be subject to further changes.

LICENCE CONDITIONS FOR THE PROVISION OF WHITE SPACE GEO-LOCATION DATABASE SERVICES

1 Scope of Services

- 1.1 The Licence enables the Licensee to establish, install, maintain and operate a white space (“WS”) geo-location database system for the provision of WS geo-location database services.
- 1.2 The Licensee shall ensure that the System is capable of the following functions:
- (a) upon request by WS devices (“WSDs”), determine and provide to WSDs, the available channels and maximum transmission power level at the WSDs’ locations; and
 - (b) provide a registration platform and repository for information relating to WSDs and the contact details of WSD users in accordance with Condition 8 of this Annex.
- 1.3 The Licensee shall ensure that the Services are hosted by servers that are physically located in Singapore.

2 Co-Channel and Cross-border Coexistence

- 2.1 To facilitate co-channel coexistence of WSDs with other radio-communication services, as well as cross-border coexistence of WSDs at or near the borders of Singapore, the Licensee shall comply with the following in the provision of the Services:
- (a) determine the separation distance between the WSD and the receiver station of each protected service as obtained from IDA in accordance with Condition 5.1 of this Annex (“Protected Service”), as well as between the WSD and the coordinates set out in Schedule B;
 - (b) calculate the path loss using the propagation model as notified by IDA to the Licensee (“Propagation Model”) between the WSD and the receiver station of each Protected Service, as well as between the WSD and the Coordinates;
 - (c) use the path loss information and noise floor level, which shall for the purposes herein be fixed at -115dBm or such other value as notified by

IDA to the Licensee, as the basis to compute the maximum permissible transmission power level for the WSD for each available WS channel; and

- (d) return the spectrum availability information and the maximum transmission power for the respective channels to the WSD that is requesting this information.

3 Management of High Priority Channels

3.1 Where the Licensee has obtained IDA's prior written approval for the Licensee to manage access to the high priority channels as notified by IDA to the Licensee ("HPCs"), the Licensee shall comply with the following:

- (a) Not allocate any HPC to any WSD unless there is no common WS channel²⁸ available to a WSD at the WSD's location at that point in time;
- (b) Allocate all HPCs using a fair process and in accordance with the allocation method which has been notified by the Licensee to IDA;
- (c) Notify IDA in writing prior to changing the allocation method of any HPC; and
- (d) Take reasonable precautions to prevent interference between the Licensee's WSD users, and between the Licensee's WSD users and other licensees' WSD users. Without prejudice to the generality of the foregoing, the Licensee shall cooperate and coordinate with other licensees who are also managing access to the HPCs, to prevent any such interference.

3.2 Where the Licensee is managing access to the HPCs, the Licensee shall obtain IDA's prior written approval before ceasing to manage such access.

3.3 IDA reserves the right to require the Licensee to change its allocation method for any HPC as necessary.

3.4 Where the Licensee has not obtained IDA's prior written approval for the Licensee to manage access to the HPCs, the Licensee shall not provide any WSD with any access to any HPC.

²⁸ Common WS channels refer to the authorised radio frequency bands as set out for WSDs in the Telecommunications (Exemption from Sections 33, 34(1)(b) and 35) Notification but excluding the channels designated as HPCs as notified by IDA to the Licensee.

4 Accuracy of Information

- 4.1 The Licensee shall ensure that the information on available channels and maximum transmission power that the Licensee provides to any WSD is accurate.
- 4.2 Where there is any inaccuracy in respect of the information described in Condition 4.1 of this Annex, the Licensee shall act promptly to resolve the inaccuracy.

5 Obtaining Current Information relating to Protected Services

- 5.1 The Licensee shall obtain from IDA, once every 6 hours, current information in relation to the Protected Services.
- 5.2 IDA reserves the right to require the Licensee to obtain current information in relation to the Protected Services on a more frequent basis or at such specific timings as notified by IDA.

6 Pricing, Terms and Conditions

- 6.1 The Licensee shall inform IDA of their pricing, terms and conditions for the provision of the Services prior to any commercial launch or public announcement for the provision of the Services.
- 6.2 IDA reserves the right to regulate any of the pricing, terms and conditions as IDA deems fit.

7 Security Requirements

- 7.1 The Licensee shall establish communications authentication procedures, and notify IDA in writing of the communications authentication procedures adopted by the Licensee, for the purpose of ensuring that data received by any WSD in connection with the provision of the Services by the Licensee is from an authorised source.
- 7.2 The Licensee shall take all reasonable precautions to ensure that all communications between the System and the WSDs cannot be accessed, altered or otherwise affected by any unauthorised person.
- 7.3 IDA reserves the right to require the Licensee to comply with any other security requirement as necessary.

8 Registration and Repository of WSD Information

- 8.1 The Licensee shall provide and maintain a registry for users of Fixed WSDs²⁹ to register and store the following information:
- (a) Unique Device Identifier (“Unique ID”);
 - (b) Device geographic coordinates such as the latitude and longitude;
 - (c) Height of the WSD antenna;
 - (d) Name of individual or business that is responsible for the device;
 - (e) Name of a contact person responsible for the device’s operation;
 - (f) Address of the contact person;
 - (g) Email address of the contact person; and
 - (h) Phone number of the contact person.
- 8.2 The Licensee shall provide and maintain a registry for users of Mode I WSDs³⁰ to register and store the Unique ID of the Mode I WSD, and the Unique ID of the relevant Fixed WSD or Mode II WSD³¹ through which the Mode I WSD is accessing the Services provided by the Licensee.
- 8.3 The Licensee shall provide and maintain a registry for users of Mode II WSDs to register and store the Unique ID of the Mode II WSD.
- 8.4 The Licensee shall store and maintain the information in the registries described in Conditions 8.1, 8.2, 8.3 and 8.5 of this Annex for a period of not less than 6 calendar months from the date of termination of the Services to the customer, and the registries shall be made available for inspection by IDA.
- 8.5 IDA reserves the right to require the Licensee to record any other details as necessary in its registries.

²⁹ “Fixed WSD” refers to a device which is operating in a fixed geographic location and with a maximum transmission power of 4 W EIRP.

³⁰ “Mode I WSD” refers to a device which is operating on a portable basis, in conjunction with a Fixed or Mode II WSD, and with a maximum transmission power of 100 mW EIRP.

³¹ “Mode II WSD” refers to a device which is operating on a portable basis and with a maximum transmission power of 100 mW EIRP.

9 Discontinuation of Operations

- 9.1 The Licensee shall not transfer the control or ownership of the System or any of its records to any other person unless prior written approval has been obtained from IDA.
- 9.2 The Licensee shall ensure that it has an adequate business continuity plan (“BCP”) in place, and submit a copy of such BCP to IDA. Where the Licensee makes any change to its BCP, the Licensee shall also promptly provide IDA with an updated copy.
- 9.3 IDA reserves the right to require the Licensee to include additional steps, measures or precautions as part of the Licensee’s BCP as necessary.
- 9.4 In any event where the business continuity of the Licensee is or may be affected, the Licensee shall follow its BCP to the fullest extent possible and as appropriate under the circumstances in order to ensure the continuity of the provision of its Services.

10 Access to WSD Information

- 10.1 The Licensee shall provide IDA with the relevant rights to obtain current WSD information that is stored within its System for the purpose of investigating any alleged or actual interference with the operation of any authorised station or network.
- 10.2 The Licensee shall, where required by IDA, restrict the availability of WS channels for WSDs that do not conform to the relevant IDA Technical Specifications, or that interfere with the operation of any authorised station or network.

**REVISED SEQUENCE OF OPERATIONS BETWEEN A WSD AND
THE GEO-LOCATION DATABASE**

