Stakeholder workshop

TV white spaces: A consultation on white space device requirements

3 December 2012

Outline

- Introduction
- Background
- Requirements for WSDs
- Parameters
- Draft regulatory and technical deliverables
- Next steps

Introduction

- "White space spectrum" refers to frequencies that are not being used by existing licensees at all times or at all locations. A white space device (WSD) can make use of these frequencies provided that the risk of harmful interference to the licensed users of the spectrum can be appropriately managed.

- Location-aware wireless devices, assisted by databases which provide information on white space availability taking into account existing licensed use, offer the promise of opportunistic access to under-utilised frequency bands for innovative services.

- We believe that such database-assisted operation can be a key enabling technology for the efficient and dynamic sharing of spectrum in a variety of frequency bands.

- This consultation addresses the requirements that we consider are necessary for wireless apparatus to use the white spaces of the UHF TV band without causing harmful interference.

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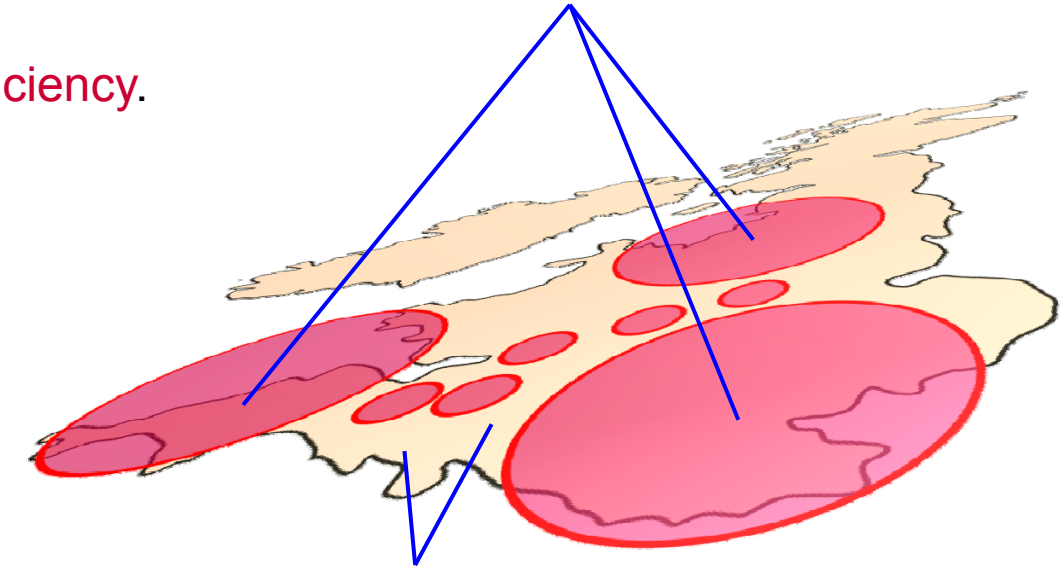
TV white spaces

- "*White spaces*" refer to geographical areas where the radio spectrum is not used by the existing licensee.

- White space spectrum can be potentially accessed by users other than the licensee, resulting in
  - increased overall spectrum efficiency.
  - innovative new services.

- Protection of the incumbent licensee(s) is paramount.

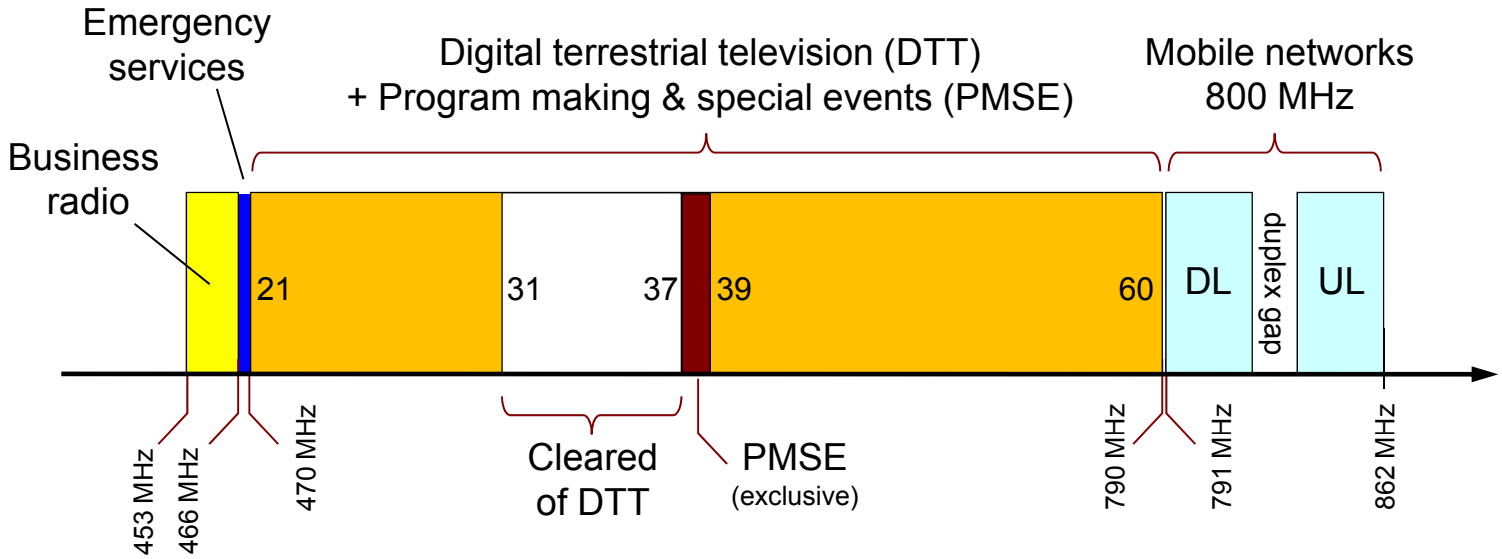
High power TV broadcasts using the same frequency need to leave spaces between their coverage areas to avoid interference.



These frequencies can be used in the "white spaces" in between by lower-power devices.

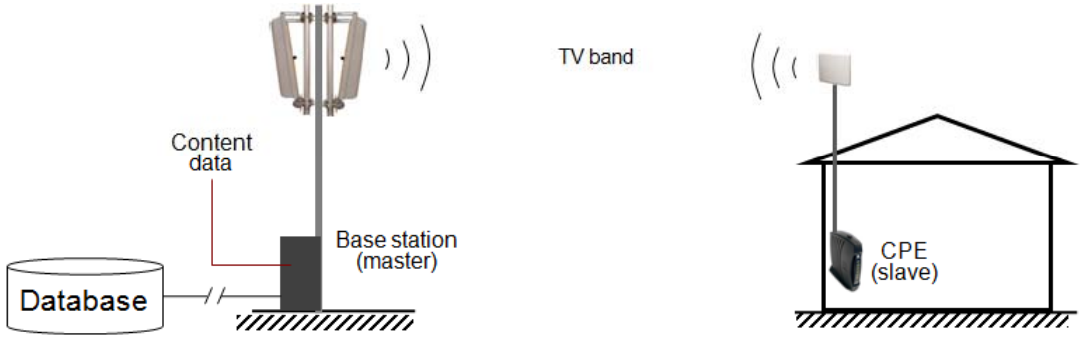
The UHF TV band and existing services in the UK

- Access to the UHF TV band by white space devices (WSDs) would be subject to the appropriate protection of existing services.



Use cases for WSDs

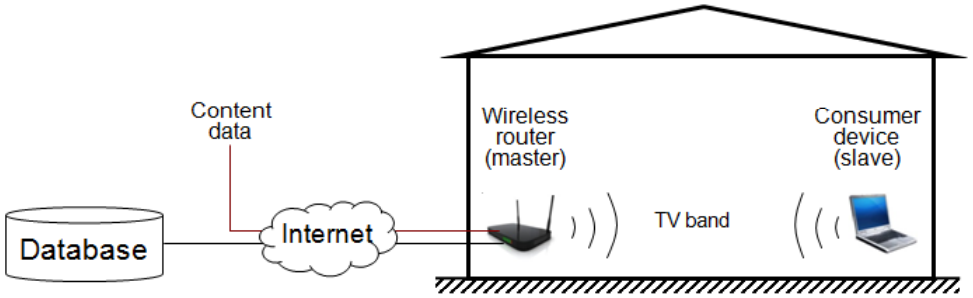
- Use cases include:
  - Rural broadband
  - Hot-spot coverage
  - In-home broadband
  - In-home multi-media
  - Machine-to-machine



Rural broadband
or utility meter reading (machine-to-machine).

- Main driver:

  Favourable propagation characteristics of radio waves in the UHF TV band, and their ability to penetrate deep inside buildings.



In-home broadband, in-home multi-media distribution,
or indoor public hot-spot coverage.

The path towards access to TV white spaces

Ofcom's consultations

White space access should be allowed in principle and be licence exempt, provided no interference is caused to licensed services.

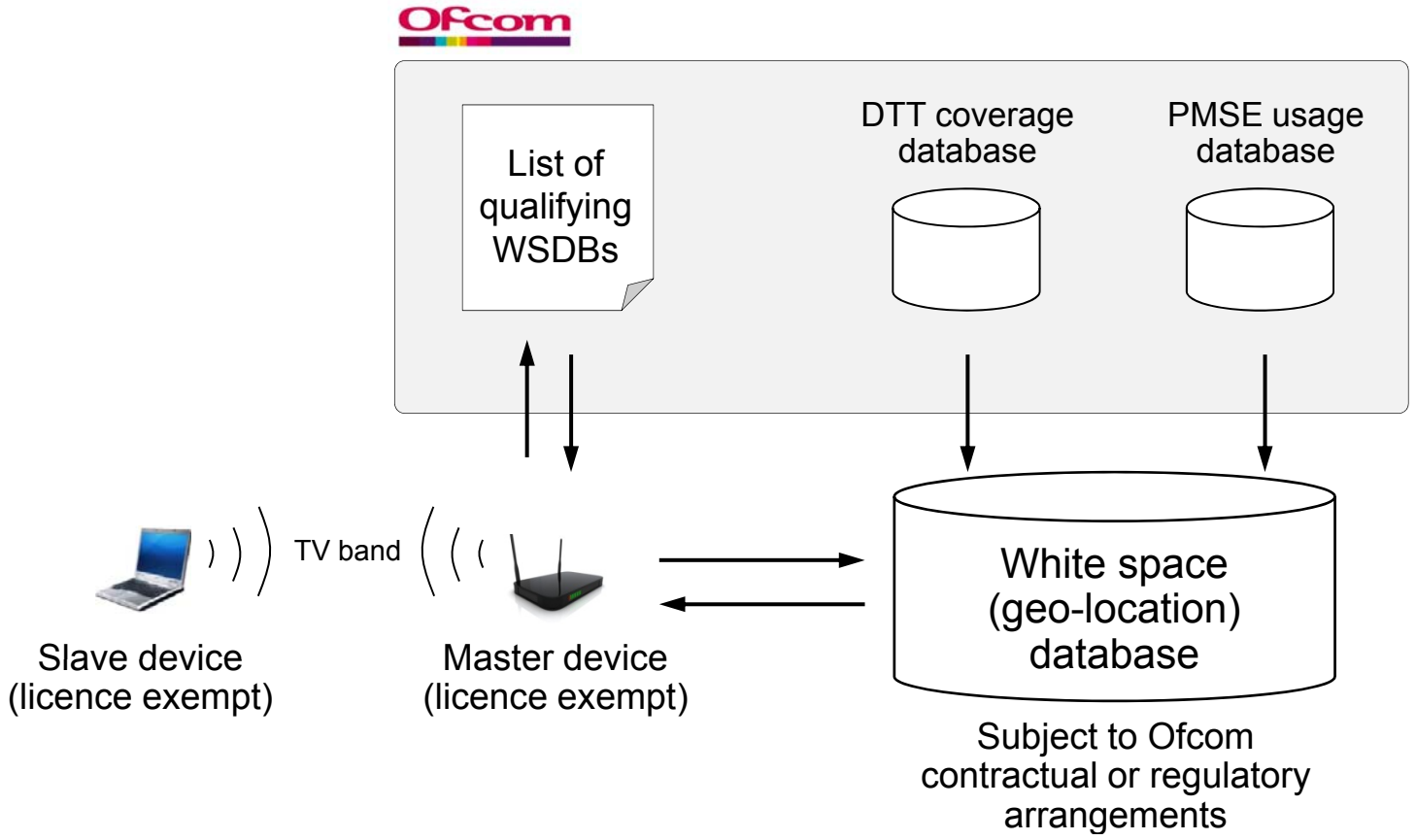
Initial views on white space database ownership, information exchange between databases and WSDs.

Autonomous vs. database-assisted.

Geolocation was the most promising way for a WSD to gain access to spectrum in the short-medium term. Sensing is also an option in the longer-term.

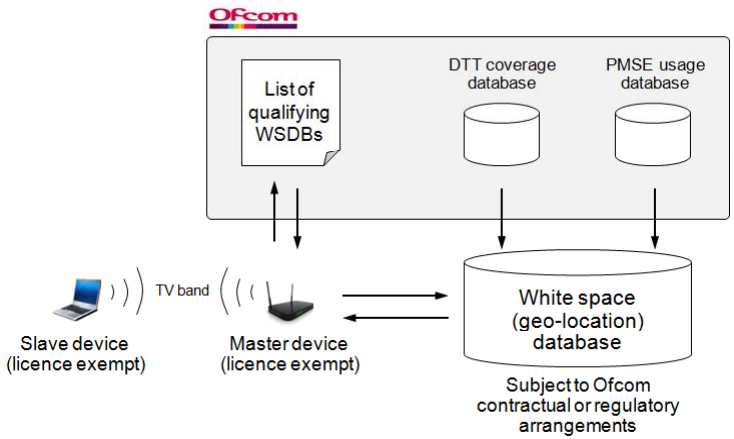
Initial views on approach to making WSDs licence exempt, high-level requirements on databases and database providers.

Adopted framework (September 2011)



Adopted framework (September 2011)

- WSDs should not cause undue interference to incumbent licensed users.
- WSDs will be licence exempt provided they comply with requirements captured in a statutory instrument.
- Compliance with exemption regulations will require that WSDs operate according to frequency/power (f, P) parameters that they receive from a qualifying WSDB.
- A qualifying WSDB will generate (f, P) parameters for WSDs based on information relating to protection of incumbent users that Ofcom will regularly make available.
- WSDs will be able to identify qualifying WSDBs by consulting a list on a website maintained by Ofcom, and select a preferred WSDB from that list. The choice of preferred WSDB will be for the master WSD to determine itself.



Adopted framework (September 2011)

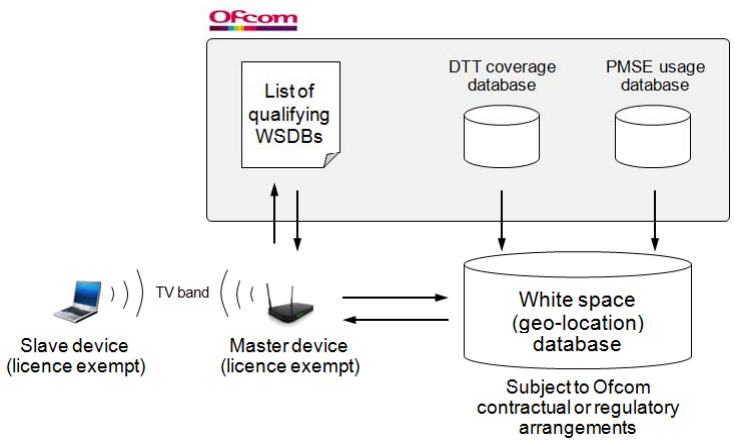
- To be included on this list, WSDB providers will have to satisfy Ofcom that they are qualified to provide WSDB services. Ofcom and each WSDB provider will enter into arrangements that specify the obligations applying to the provision of qualified WSDB services.

- WSDs may be a master or a slave.

  A master is required to have

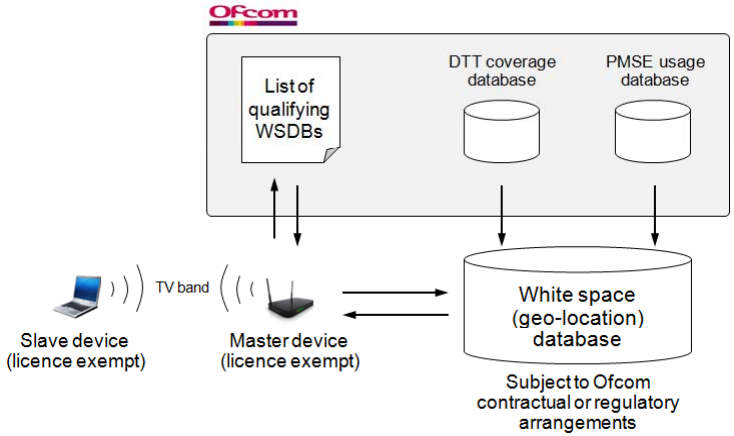
  - a communications link to access Ofcom's list of qualifying WSDBs, and
  - a communications link to query one of the qualifying WSDBs.

  A slave WSD does not have a direct connection to Ofcom or a WSDB; it will obtain its (f, P) parameters from a WSDB through a master WSD.



Adopted framework (September 2011)

- A WSDB may be “open” or “closed”. An open WSDB provides services to any WSD. A closed WSDB only serves a closed group of WSDs. It will be for the WSDB operator to determine its commercial arrangements with WSDs.
- A WSDB must provide frequency/power parameters to WSDs on a non-discriminatory basis; i.e., a WSDB must provide the same parameters to all WSDs which have the same device characteristics and are in the same geographic location.
- The number of qualifying WSDBs will not be capped.
- A WSDB may provide supplementary “value-added” services to devices. An example of this could be a classification of the available channels according to their quality.



Our work on TVWS policy (Since September 2011)

Device requirements and licence exemption

- This is the subject of this consultation.
- We have engaged extensively with stakeholders over the past year within a technical working group to discuss the requirements for regulation and technical specification of WSDs.
- We have now created a framework for the operation of WSDs that is implemented through three draft documents setting out the proposed requirements:
  - Example draft statutory instrument (SI)
  - Draft interface requirement (IR)
  - Voluntary national standard (VNS)

Our work on TVWS policy (Since September 2011)

Co-existence with existing services

- We have engaged closely with stakeholders over the past six months, to discuss the technical parameters for co-existence between WSDs and the DTT and PMSE services.
- These discussions have been informed by
  - measurements of protection ratios for DTT and PMSE receivers, and
  - measurements and modelling of interferer-victim geometries and coupling.
- We have not yet decided on the co-existence parameters.
- Our studies in this area are on-going,
  but are expected to be completed in early 2013.
  We intend to subsequently consult on our proposals.

Our work on TVWS policy (Since September 2011)

Database requirements and qualification

- Our framework involves Ofcom entering into arrangements with WSDB providers who have demonstrated that their WSDBs meet certain requirements and are able to provide the (f, P) parameters and other instructions to WSDs.

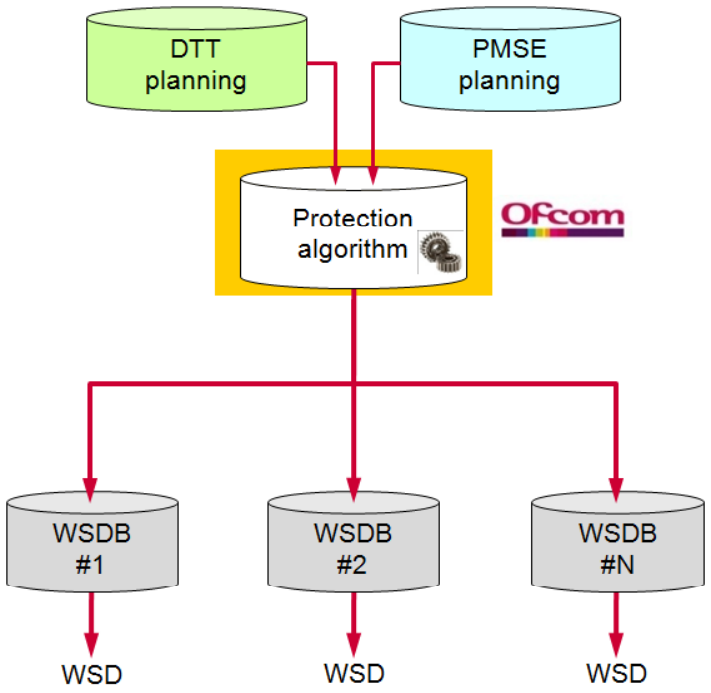
- We are working to develop the details of the WSDB requirements and to translate these into contractual terms. We expect to engage with stakeholders to discuss the substance of these.

- We are also considering holding an "end to end" trial to test the interoperation of Ofcom's systems, with WSDBs and devices. We are also evaluating the impact of the WSDB approach on Ofcom's operations.

Our work on TVWS policy (Since September 2011)

Making information on DTT and PMSE available to databases

- Our proposal in the 2011 Statement was that WSDBs would calculate TVWS availability, using the DTT and PMSE data as input.
- We are considering whether this should be the case or whether Ofcom should calculate TVWS availability in-house and then pass it on to the WSDBs.
- The main reason for the latter alternative is the complexity of the calculations and the need to ensure a consistent output from all databases. We will address this issue in the co-existence consultation mentioned above.



Our work on TVWS policy (Since September 2011)

Baseline and enhanced modes

- Our “baseline” framework for WSDs, as set out in our 2011 Statement, involves automatic reporting of device parameters from WSDs to WSDBs.
- Analysis suggests that fixed WSDs may benefit from *enhanced* TVWS availability if certain parameters (e.g., distance to nearest victim, antenna characteristics, etc.) are reported by the user of the device and accounted for by the WSDBs.
- However, this so-called “enhanced mode” raises new questions regarding the authorisation of the WSDs, and the arrangements between Ofcom, WSDBs and the organisations putting the WSDs into operation.
- In our view, these questions will be better addressed once the details of the baseline mode have been finalised. We intend to do this by publishing a consultation document on the enhanced mode.

Our work on TVWS policy (Since September 2011)

Government's Communications Review

- The Government's review asks for views on how to reduce regulatory burdens and future-proof for the digital age. A key element of this review is spectrum.

- In Ofcom's response to a DCMS discussion paper we suggested that there were potential benefits from having a clear framework for the provision, management and regulation of databases (and their providers) that perform the function or have the effect of managing access to spectrum. We also noted that we should have the ability to the recover the costs involved in this way of managing spectrum.

International activities

- We have contributed to a number of key European activities, including the work of:
  - ECC SE43 in defining the co-existence parameters for the operation of WSDs;
  - ETSI BRAN in defining European harmonised standard (EN 301 598).

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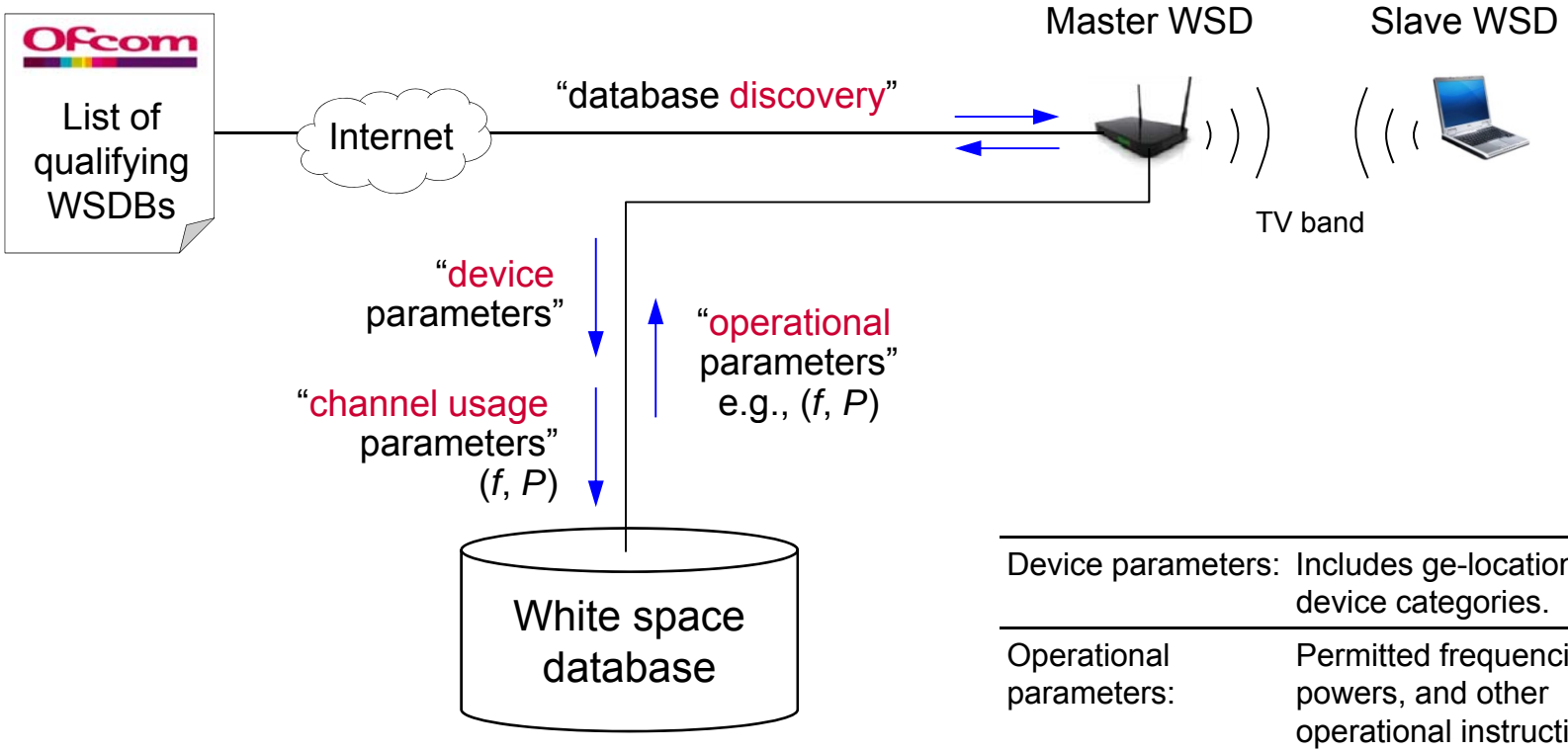
Ofcom's duties

- Our principal duties are towards citizens and consumers.
- With regards to spectrum, our key duties are to ensure optimal use and promote benefits such as innovation and competition.
- We have interpreted these duties as requiring us to
  - facilitate access to white spaces, because there are significant benefits to consumers;
  - appropriately protect DTT and PMSE. DTT is very important for consumers, and also from a public service perspective. PMSE equipment is used in a range of activities generating important economic and social value;
  - minimise the regulatory burden. We need to have regulation to enable use of TV white spaces and to protect incumbents, but we have tried to keep this to a minimum.

Framework re-visited + terminology



Device parameters:	Includes ge-location and device categories.
Operational parameters:	Permitted frequencies and powers, and other operational instructions.
Channel usage parameters:	Used frequencies and powers.

High level requirements

- We have set out a sequence of information exchange between WSDBs, master WSDs, and slave WSDs. These reflect the following high level requirements:
  - A qualifying WSDB must receive information from a WSD about the characteristics of that WSD in order to generate operational parameters for that WSD.
  - A qualifying WSDB must maintain a record of the usage of the TVWSs. This means that each device must report back to the WSDB the actual frequencies and powers that it uses. We believe this is important for the purpose of spectrum management for two reasons:
    - To enable offending WSDs to be readily identified if interference occurs.
    - To allow the WSDBs (and Ofcom) to know the extent to which available white spaces are being used.

High level requirements

- We acknowledge that a range of WSD technologies are likely to emerge, so we have defined the requirements to be technology-neutral.
- We have specified the sequence of operations at a high level, with only enough detail to ensure that necessary information is exchanged between WSDs and WSDBs.
- We do not believe that our requirements impose constraints on industry-led innovation in this field, or on the emergence of technology standards which specify the details of the communication protocols.
- We recognise that the requirement to report back to the WSDB the actual usage parameters is not present in other licence exempt use. However, we believe that the circumstances of licence exemption in the UHF TV band make it important to keep track of actual use.
- The reporting of actual use is relatively straightforward to implement once the database and the communications infrastructure are in place.

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Device categories (a subset of device parameters)

- These are:

  1) Device Type (A/B: fixed outdoor/other)
  2) Emission class (spectral leakage)
  3) Radio technology (time-frequency signal structure)

- The categories identify WSDs with different deployment and performance characteristics. These allow manufacturers the flexibility to create WSDs at a range of cost points, and for the industry to match these to different use cases.

- The reporting of the WSD categories to WSDBs ensures that WSDs that are less likely to cause interference to existing users are allowed to transmit with more relaxed constraints.

- The overhead of signalling the categories to a WSDB is a small fraction of the signalling capabilities of a modern wireless device. Furthermore, the requirement for WSDBs to create category-specific operational parameters is readily manageable given the state-of-the art in computing technology.

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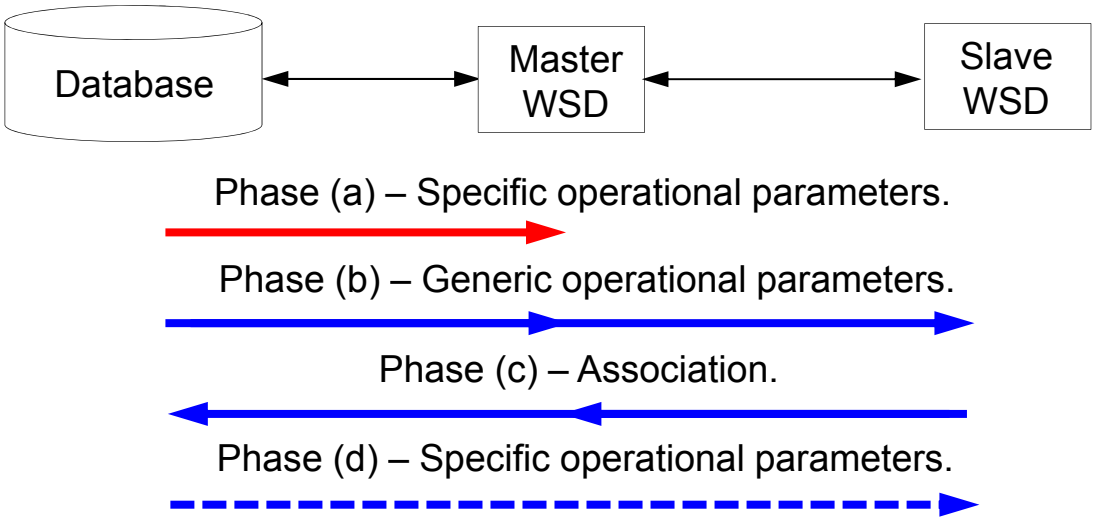
Sequence of operations

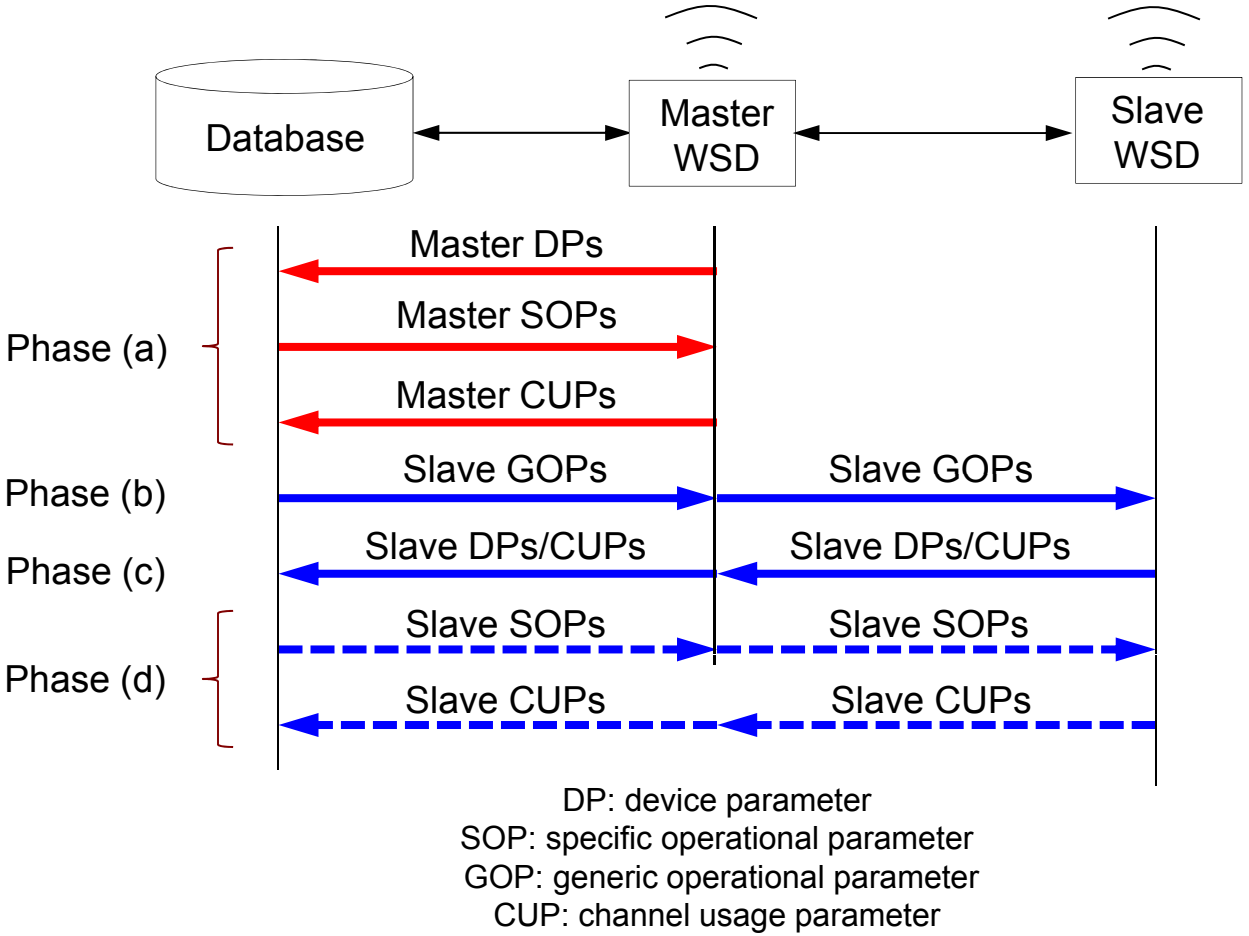
- We define the sequence of operations as four phases.
- These will be preceded by WSDB discovery.



- We use the term "association" to refer to the process whereby a slave WSD initially identifies itself to its serving master WSD.

- Phase (d) is optional if association is over the UHF TV band.

Parameter exchange



DP: device parameter
SOP: specific operational parameter
GOP: generic operational parameter
CUP: channel usage parameter

- Device parameters must be determined automatically by WSDs to reduce risk of tampering and false reporting.

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Discovery of qualifying databases

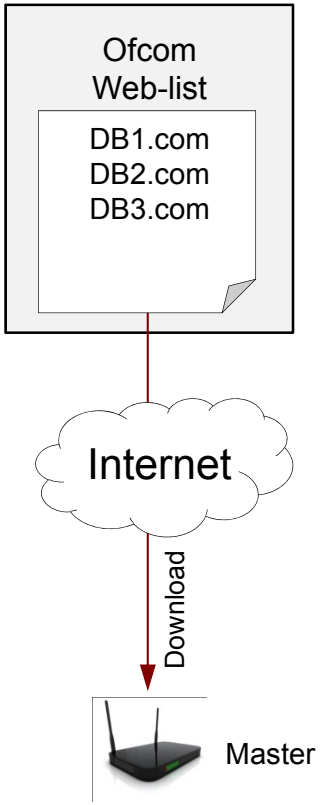
https://TVWS-DB.ofcom.org.uk.

- When operating in the UK, a master WSD must *discover* qualifying WSDBs by regularly consulting a device-readable list of qualifying WSDBs provided at a website maintained by Ofcom. That list will be based on the list of qualifying databases that will be set out in a schedule to the SI.

- The list will be updated regularly to reflect which of the qualifying WSDBs are currently in operation. This is because Ofcom may from time to time require qualifying WSDBs to suspend white space services for a period of time.

- A master WSD must cease communications within the UHF TV band if more than N minutes have elapsed since it last successfully discovered a qualifying WSDB as defined on Ofcom's device-readable list. In this way, WSBDs that no longer qualify, or qualifying WSDBs whose operations are suspended, can be removed from the device-readable list, and no WSD will contact a removed WSDB after N minutes have elapsed.

- As a default, N will be set to correspond to 24 hours.



Ceasing of transmissions

- The following requirements implement a so-called WSDB "kill switch" to disable individual WSDs in the event of interference to existing users:
  - A master WSD (and its served slave WSDs) must cease transmission within 60 seconds of receiving instructions to do so by the WSDB.
  - A slave WSD must cease transmission within one second when instructed to do so by its serving master WSD.
- A slave WSD must also cease transmissions if it loses communications for more than five seconds with the master WSD from which it has received its slave operational parameters.
- This addresses the risk that the slave WSD moves outside the coverage area of its associated master WSD, and continues to transmit at frequencies and powers that are no longer permitted.

Geographic and time validity

- A master (or geo-located slave) WSD can move up to 50 metres in any (horizontal) direction without needing an update to its specific operational parameters. Conversely, if the WSD moves more than 50 metres in any (horizontal) direction, then it must request an update to its specific operational parameters[1].

- The time validity is itself included in the operational parameters and is necessary to ensure that master WSDs re-consult WSDBs with sufficient frequency to keep up to date with the dynamic nature of spectrum use by the PMSE service.

[1] If the WSD is a master, it must also request an update to the generic operational parameters of the slaves in its coverage area.

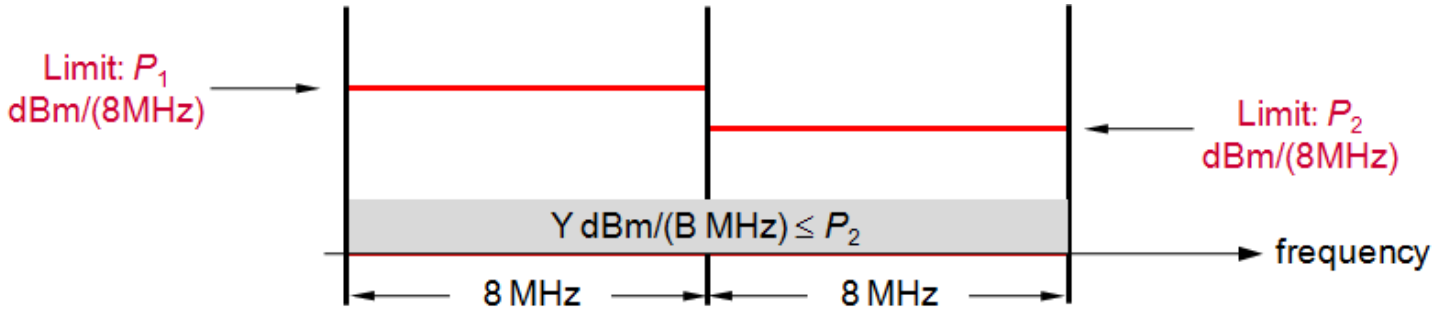
Multi-channel operation

- If a WSD were to radiate proportionally greater powers with increasing bandwidths, there would be a significant risk of interference. The following rules are necessary to deal with multi-channel WSD radiation.

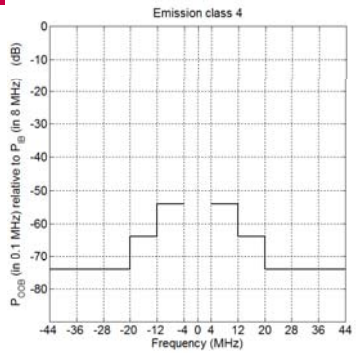
- A WSD which transmits simultaneously over multiple DTT channels must

  - comply with the maximum permitted in-block EIRP spectral densities in each of the DTT channels to be used; and

  - radiate with a total in-block EIRP (measured over the total number of DTT channels to be used) which does not exceed the smallest of the maximum permitted in-block EIRPs specified over each of the DTT channels to be used.



Out-of-block emissions



- The out-of-block EIRP spectral density, P_{OOB}, of a WSD must satisfy

$$P_{OOB(dBm/(100\,kHz))} \leq \max\left(P_{IB(dBm/(8\,MHz))} - AFLR(dB), -84\right)$$

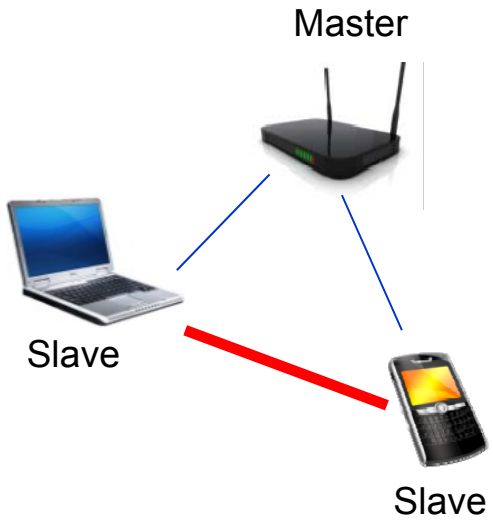
where P_{IB} is the WSD's in-block EIRP spectral density, and AFLR is the WSD's adjacent frequency leakage ratio outlined in the table below for different device emission classes.

Where falls within the n^{th} adjacent DTT channel	AFLR (dB)			
	Class 1	Class 2	Class 3	Class 4
n = ±1	74	74	64	54
n = ±2	79	74	74	64
|n| ≥ 3	84	74	84	74

- The absolute value of –84 dBm/(100 kHz) is specified to account for the difficulty in maintaining a high leakage ratio at very low in-block EIRPs.

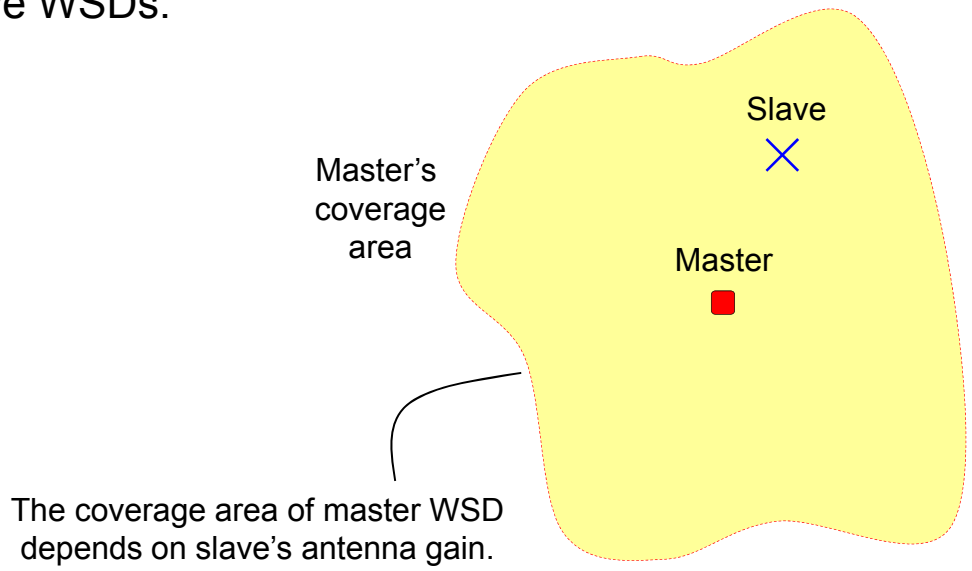
Slave to slave communications

- A slave WSD may communicate with another slave WSD provided that it maintains communication over the UHF TV band with its serving master WSD and remains under the control of the said master WSD.
- This is to ensure that slave WSDs do not operate autonomously and that they continue to transmit subject to the operational parameters received from their respective master WSDs.



Slave antenna gain

- The antenna gain of slave WSDs is an important parameter.
- This is because when calculating generic operational parameters, a WSDB needs to estimate the possible locations of slave WSDs based on the expected coverage area of their serving master WSD. To do so, the WSDB will need to assume a specific value for the slave WSD receiver antenna gain.
- We are considering whether to specify a limit on the maximum receiver antenna gain of slave WSDs.



Security

- Communications between a master WSD and the website which contains Ofcom's list of qualifying WSDBs should be performed using secure protocols that avoid malicious corruption and unauthorised modification of data, and ensure that WSDs communicate with the correct website. For this reason, we propose that that the website be accessed using the HTTPS protocol.

- Communications between a master WSD and a WSDB must be performed using secure protocols that avoid malicious corruption or unauthorised modification of the data. We expect these security protocols to be addressed by technology standardisation organisations.

- Communications between a master WSD and a slave WSD for purposes of relaying WSDB-related instructions and parameters must be performed using secure protocols that avoid malicious corruption or unauthorised modification of the data. We expect these security protocols to be specified within wireless technology standards.

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Device parameters

- Unique device identifier
- Emission class
- Technology identifier
- Device type (A/B)
- Device model identifier
- Device master/slave category
- Antenna latitude/longitude coordinates and accuracy (optional for slaves)
- Antenna height above sea level and accuracy (optional)

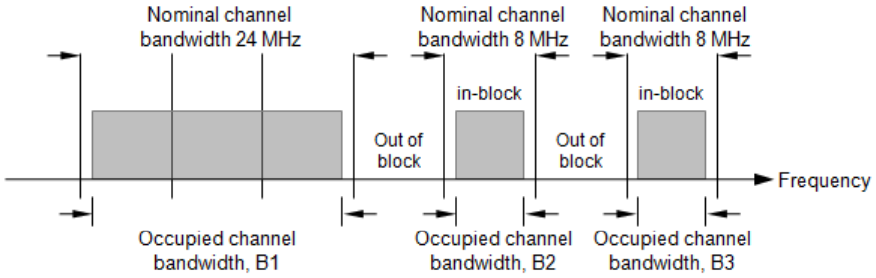
- We believe that the above parameters are justified in the context of spectrum management, and that they only introduce a minimal overhead for their signalling to a WSDB.

Operational parameters

Parameter	Format / Definition
List of lower and upper DTT channel edge frequencies	The i^{th} lower and upper edges shall be specified as $F_{L,i}$ = (470 + 8k_i) MHz, and $F_{U,i}$ = (470 + 8k_i + 8) MHz, where $0 \le k_i \le 39$.
Maximum permitted in-block EIRPs for each DTT channel edge frequency pair	Specified as $P_{0,i}$ dBm in 0.1 MHz and $P_{1,I}$ dBm in 8 MHz over the frequency interval $F_{L,i}$ to $F_{U,i}$.
Maximum permitted nominal channel bandwidth, and maximum total nominal channel bandwidth	$B_C = K_C \times 8$ MHz (contiguous), $B_T = K_T \times 8$ MHz where K_T, $K_C > 0$.
Time validity of operational parameters	T_{Val} specified as absolute time in 24 hour clock format (hour:min) with reference to GMT. For slaves, this might be specified as relative time.

Channel usage parameters

Parameter	Format / Definition
List of lower and upper DTT channel edge frequencies within which a WSD intends to transmit	The i^{th} lower and upper edges shall be specified as $f_{L,i}$ = (470 + 8k_i) MHz, and $f_{U,i}$ = (470 + 8k_i + 8) MHz, where 0 ≤ k_i ≤ 39.
In-block EIRP spectral densities which a WSD intends to use within each DTT channel	Specified as $p_{0,i}$ (dBm/0.1 MHz) and $p_{1,i}$ (dBm/8 MHz) over the frequency interval $f_{L,i}$ to $f_{U,i}$.



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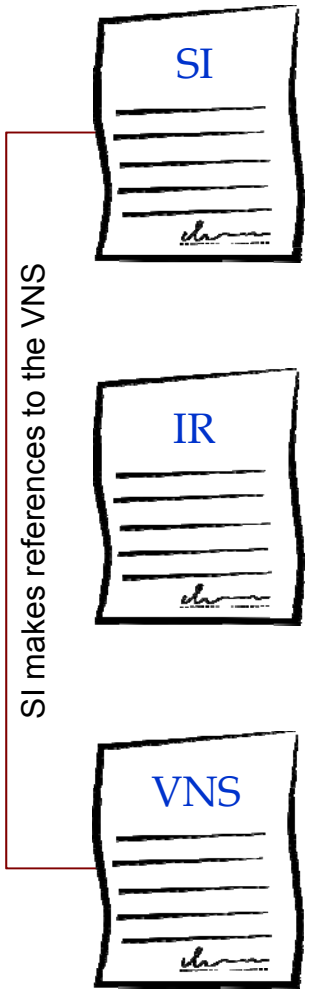
Structure…



- **Example Statutory instrument**

  Describes the terms and conditions with which WSDs must comply to benefit from exemption from licensing under the WT Act.

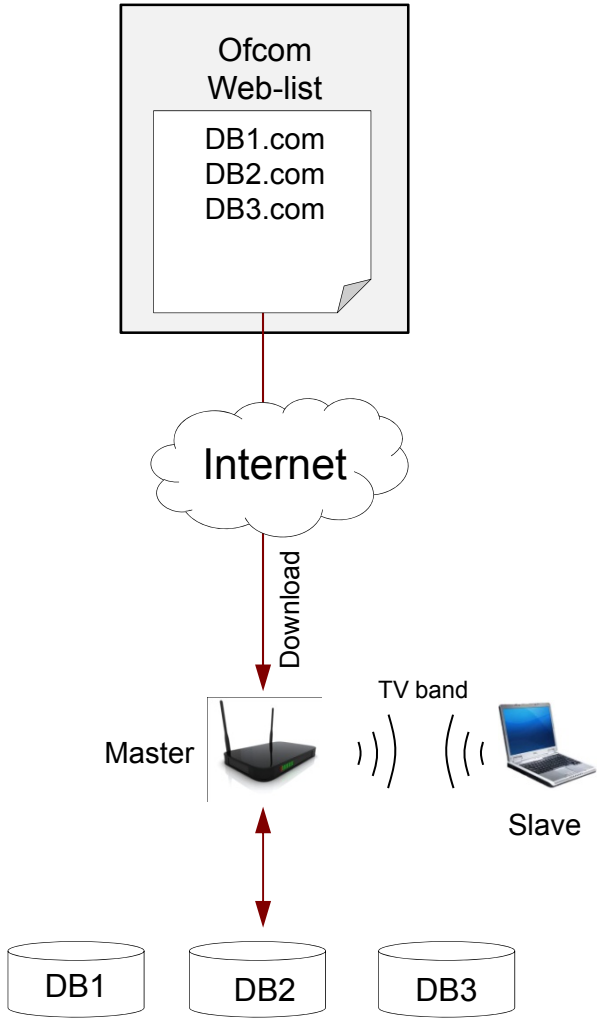
- **Draft Interface requirement**

  A technical description of the provisions in the SI, used for the purpose of notifying the EC of our proposed technical regulations. Also identifies requirements in the VNS which Ofcom considers to be key device features for compliance with the essential requirements of the R&TTE Directive, specifically to avoid harmful interference.

- **Draft Voluntary national specification**

  Provides guidance to manufacturers and will be superseded by the ETSI harmonised standard when the latter becomes available. The VNS sets out the technical specifications that we consider WSDs should comply with to operate without causing harmful interference.

https://TVWS-DB.ofcom.org.uk.



Example draft statutory instrument

- **Regulation 3** – This provides that wireless telegraphy equipment used for the purposes of accessing TV white spaces will be exempt from the provisions of Section 8(1) of the WT Act, provided that the requirements in Regulations 4, 5 and 6 are met.

- **Regulation 4** – This sets out terms of the exemption that apply to all WSDs.

  - These include the frequency range of operation, restrictions on airborne use, the distinction between masters and slaves, the operational parameters a WSDB will provide to a master (specifying the transmission conditions for the master or any slave that the master may serve).

  - It refers to the VNS and requires that WSDs offer a similar level of protection from undue interference to other users of the spectrum that is provided for in the VNS.

  - It also sets out a general requirement that WSDs must not cause undue interference.

Example draft statutory instrument

- **Regulation 5** – This sets out the terms of exemption for master WSDs.
  - In particular, a master must:
    - not request operational parameters from anyone other than a qualifying WSDB (qualifying WSDBs being listed in a schedule to the SI); and
    - transmit only in accordance with the operational parameters received from a qualifying WSDB and only within the geographical area in which the parameters are valid.
  - Also described are the device parameters that a master must provide to a WSDB; the information that a master WSD must provide to a WSDB about its intended transmissions; the requirement for masters to cease transmissions in the UHF TV band within 60 seconds of receiving an instruction to do so.
  - Also described are requirements for masters when they serve slaves. A master must
    - only communicate operational parameters to slaves where those parameters have been received from a qualifying WSDB; and
    - forward certain information that it receives from a slave to a WSDB.

Example draft statutory instrument

- **Regulation 6** – This sets out the terms of exemption for slave WSDs.
  - In particular, a slave must transmit only in accordance with the operational parameters it has received from a master and, if the slave is a geo-located slave, only within the geographical area in which the parameters are valid.
  - Also specifies that a slave must:
    - transmit in accordance with either generic or specific operational parameters;
    - provide certain information to its serving master WSD on receipt of generic and specific operational parameters,
    - cease transmissions in the UHF TV band: a) within one second of receiving instructions from a master to do so; or b) if the slave loses communications with its serving master for more than five seconds.

Draft interface requirement

- The IR is the template agreed by member states and the European Commission (EC) for the purpose of member states' notification of technical regulations to the EC.
- The proposed IR contains a technical description of the provisions in the SI. These are the minimum requirements with which devices must comply.
- Together with the "essential requirements" detailed in Article 3.2 of the R&TTE Directive, these requirements constitute the minimum requirements for WSDs in the UHF TV band in the UK.
- In addition, the proposed IR identifies a number of requirements which are contained in the VNS and which Ofcom considers to be key features of the device to achieve compliance with the essential requirements of the R&TTE Directive, specifically to avoid harmful interference.

Draft voluntary national specification

- In order to declare conformance with the R&TTE Directive, device manufacturers must satisfy the “essential requirements” of the Directive. ETSI has the mandate to develop harmonised standards. Compliance with these harmonised standards is not mandatory, but it is a route to show presumption of conformity with the “essential requirements” of the Directive.

- ETSI is currently developing a draft harmonised standard for WSDs operating in the UHF TV band. Whilst awaiting publication of the standard, Ofcom has produced a VNS. This VNS will be superseded when the ETSI standard is available. We are actively contributing to ETSI to ensure that the ETSI standard contains all the requirements that we consider necessary to demonstrate presumption of conformity with the essential requirements of the R&TTE Directive.

- The VNS contains the technical specifications that have been described in this consultation, in addition to a number of further radio frequency (RF) requirements. The VNS also contains the test procedures for compliance with the above technical specifications.

Outline

- Introduction
- Background
- Requirements for WSDs
- Parameters
- Draft regulatory and technical deliverables
- Next steps

Next steps

Device requirements (current consultation)

- This consultation, published on 22 November 2012, will last seven weeks. The closing date for responses is 10 January 2013.

- Following closure of the consultation, we will review the responses and will, where appropriate, amend the example SI and draft IR, and VNS before notifying the European Commission of these documents. In parallel, we will publish a statement on the outcome of the present consultation. We hope to do these in the first quarter of 2013.

- Following the notification to the EC and expiry of a three month "standstill" period, and on the basis that no detailed opinions have been received, we will be in a position to undertake the one month statutory UK consultation on the draft SI. We intend to do this once the first WSDBs have successfully undergone Ofcom's qualification process. This will be followed by a statement on the adoption of the SI.

Next steps

Database requirements and qualification

- We are still developing the details of the WSDB requirements and translating these requirements into a draft database contract for WSDBs and Ofcom.
- Once the work has sufficiently progressed we will publish the WSDB requirements and a draft contract. We expect this to happen in the first half of 2013. We will then discuss these with stakeholders through a series of workshops.
- We are also considering holding an end to end trial to test the interoperability of Ofcom systems, WSDBs and devices, and to help us fine tune the contract.
- Once we are confident that the draft contract addresses all required aspects of the relationship, in particular when it comes to dealing with interference, we expect to start the process of entering into contracts with WSDB providers and carrying out the assessment of the WSDBs' compliance with the qualification requirements.

Next steps

Co-existence with incumbent services

- We have engaged with stakeholders on the technical parameters for co-existence between WSDs and incumbent users.
- We have not yet decided on the parameter values.
- We intend to publish a consultation document to summarise our proposals in the first half of 2013.
- We will also include in that consultation the proposed role of Ofcom in quantifying the TVWS availability across the UK subject to the defined co-existence criteria.

Next steps

Enhanced mode

- Our *baseline* framework, described in our statement of 2011, involves the automatic reporting of device parameters from WSDs to WSDBs.
- Analysis has indicated that fixed WSDs may benefit from *enhanced* TVWS availability, if certain parameters of these devices are reported by the WSD user.
- This “enhanced mode” raises questions regarding device authorisation and Ofcom’s arrangements with the WSDB providers and the organisations putting the devices into operation.
- We aim to return to the “enhanced mode” once the details of the “baseline mode” have been finalised. We intend to do this by publishing a consultation.