

OFCOM TV White-Space consultation

Response from Neul Ltd, November 2013

1. Introduction

This document is a response from Neul to the consultation on "TV white spaces: approach to coexistence".

Neul appreciates the efforts that have been made in the consultation document to ensure that protection ratios for DTT and PMSE are not set so conservatively that the utility of TV White Space would be severely compromised. Neul believes that the proposed approach is a fair judgement of the real likelihood of interference with DTT and PMSE receivers. We also feel that the availability of TV White Space at usable power levels is at the limits of what is viable for commercial deployments, especially in urban and sub-urban regions. Therefore, we believe that any subsequent tightening of protection ratios would be very detrimental to the commercial use of TV White Space.

Neul's interest in TV White Space is primarily to enable deployments of M2M or Internet of Things (IoT) communication systems. IoT is widely considered to be a major growth area over the coming years, and furthermore existing cellular networks have disadvantages for delivering M2M traffic particularly when terminal power consumption is of critical importance.

We note that certain aspects of the consultation document appear to have been driven by applications that are concerned with broadband delivery, which is understandable given that rural broadband is a strong candidate application for exploiting TV White Space. However, we believe that three aspects of the document have a detrimental impact on deploying an M2M communications system in TV White Space, and we propose some specific changes to the proposed regulations to overcome these issues:

- The conversion of the power limit for protection of DTT, calculated in an 8 MHz bandwidth, into a power spectral density limit measured in 100 kHz, thus imposing a far more stringent power limit on any system that occupies a fraction of the 8 MHz channel. *This is our most significant concern with the consultation document since it has a major impact on a typical M2M network deployment in White Space.*
- The calculation of the coverage area of a White Space master, which is relatively conservative and so can result in generic operating parameters that are much more constraining than the specific operating limits.
- The assumption that any Type B device that is at a height of less than 2 metres is considered to be outdoors so cannot benefit from the nominal building penetration loss in computing the coupling gain.

These issues are discussed in detail in the following sections.



2. Power spectral density limit for DTT protection

Equation 3.2 in clause 3.34 of the consultation document states that the maximum power spectral density limit is calculated as:

 $P0 = \min[P1 - 10log_{10}(80), P_{WSD-PMSE}]$

where P1 is the in-block EIRP measured in an 8 MHz bandwidth for DTT protection, and $P_{WSD-PMSE}$ is the maximum power spectral density measured in a 100 kHz bandwidth for PMSE protection.

We have no issue with the use of an 8 MHz bandwidth for calculating DTT protection and a 100 kHz bandwidth for PMSE protection, since these reflect the bandwidth of the DTT and PMSE signals that need to be protected, as indicated in clauses 3.7 and 3.13 respectively.

However, we have major concerns with the step of combining the P1 value with the $P_{WSD-PMSE}$ value to form a single limiting power level P0 that is measured in a 100 kHz bandwidth. For the avoidance of doubt, we have no issue with the use of a 100 kHz bandwidth for calculating the maximum power for PMSE protection, so the following discussion does not affect the application of the PMSE power limit.

Our concerns are as follows:

- The conversion of the power limit for DTT protection to a 100 kHz bandwidth has a substantial negative impact on the allowed transmit power from any system that uses only a fraction of the 8 MHz channel for its transmissions. Due to the modest availability of White Space channels at reasonable power levels in many locations, it is likely that systems will need to perform some intra-channel frequency planning between neighbouring WS masters (basestations). This would be done by allocating only a portion of an 8 MHz channel to a given basestation. However, according to clause 3.34, this would imply a 3 dB reduction in available downlink transmit power for every halving of the transmitter modulation bandwidth, with a consequent increase in infrastructure costs to ensure coverage.
- In the case of an M2M communications system, it is very likely that narrower bandwidths will be used for the uplink communication in order to provide frequency division multiple access for transmissions from different slaves. This is a very important aspect of an M2M system in order to maintain adequate uplink capacity given that many M2M applications are uplink centric, for example sensors and alarms. As an example, the Weightless specification for an IoT network sub-divides the 8 MHz uplink channel into 20 sub-channels each of modulation bandwidth 150 kHz such that each sub-channel is assigned to a different M2M terminal during a given time slot. The current wording in clause 3.34 would reduce the available transmit power from a terminal by about 17 dB, which would make such a network unfeasible. Note that the use of code division multiple access is not practical in an M2M WAN network because it is not possible to have the necessary fast power control to avoid the near-far problem.

As an aside, even when a WS transmitter occupies the entire 8 MHz channel, it is impractical for it to have a completely flat power spectral density with no guard bands. Therefore, the effect of the



 $10log_{10}(80)$ term is to impose an artificially lower power limit on any transmitter that is limited by DTT protection. In fact, Po will always be more limiting than P1, despite the fact that clause 3.34 states that both values are communicated from the WSDB to WSDs.

For these reasons, we believe that the combining of the P1 and $P_{WSD-PMSE}$ into a single power limit, Po, measured in a 100 kHz bandwidth should be reconsidered. Specifically, we propose that instead the P1 and $P_{WSD-PMSE}$ values are passed from the WSDB to the WSD. This change would add no new complexity to the system, because it simply means that that $P_{WSD-PMSE}$ is passed to the WSD rather than Po, both of which are measured in 100 kHz bandwidth.

We appreciate that there could be some concern that interference aggregation from multiple WSDs might occur due to the division of the 8 MHz channel into multiple sub-channels, allocated to different devices. However, we suggest that there are two counter-arguments to address this concern, as described below.

Realistic number of significantly interfering devices

The conversion of P1 from an 8 MHz bandwidth to a 100 kHz bandwidth using a correction factor of $10log_{10}(80)$ is exceedingly conservative, amounting to having 80 WSDs transmitting simultaneously in a worst case location relative to a DTT receiver, such that their interference is additive in linear proportion. This does not appear to be consistent with clause 3.42 which states that interference is unlikely to aggregate in linear proportion to the number of WSDs.

We suggest that a more realistic number of simultaneously transmitting devices that could be located in a worst case location such that their transmissions significantly impact the total interference seen by a DTT receiver is 4. This number is clearly a judgement, but does provide some further level of protection against interference aggregation even though many of the points made in clause 3.41 of the consultation document still apply with regard to the likelihood of aggregation.

The result of assuming that significant interference aggregation is realistically bounded to 4 WSDs is that the $10log_{10}(80) = 19$ dB offset applied in equation (3.2) would become $10log_{10}(4) = 6$ dB.

Impact of narrowband interferers on DTT receivers

The following table shows the co-channel carrier to interference (C/I) ratios for a number of commercially available DTT receivers. The recorded numbers are the C/I ratio at which significant degradation of the DTT reception occurs for the two cases of a narrowband interferer (150 kHz 3 dB bandwidth) and a wideband interferer (5 MHz 3 dB bandwidth).

DTT receiver	C/I ratio for narrowband interferer (150 kHz bandwidth)	C/I ratio for wideband interferer (5 MHz bandwidth)
А	5	20
В	7	18
С	6.5	17
D	18	20



E	5	22
F	8	17
G	9	16
Н	12	18
Median	7.5	18

The results indicate that the median co-channel C/I ratio for a narrowband interferer is 10 dB better than for a wideband interferer. This arises from the OFDM nature of the DTT modulation which is robust to a subset of the sub-carriers being corrupted.

This addresses the potential concern that the protection ratios derived for wideband interferers might not be applicable to narrowband interferes. In fact, the results show that there is more margin in the protection ratios when the interferer is narrowband.

Proposed change to clause 3.34

In summary, we propose two options to address this issue:

- 1. [Preferred] Pass $P_{WSD-PMSE}$ and P1 from the WSDB to the WSDs, rather than P0 and P1
- 2. [If interference aggregation is perceived as a major concern] Modify equation (3.2) as follows: $P0 = \min[P1 6, P_{WSD-PMSE}]$

3. Calculation of coverage area for a WS master

The calculation of the coverage area for a WS master is important because it determines the generic operating parameters for any WS slave that wishes to communicate with that WS master. This is relevant in two scenarios:

- For WS slaves that are not geo-located, it determines the maximum transmit power from the WS slave under all circumstances. For an M2M network, many slaves may not be geo-located, so this is an important consideration.
- For WS slaves that are geo-located, it determines the maximum transmit power from the WS slave during the initial association phase between the slave and the master, prior to the master communicating the specific operating parameters to the slave. For an M2M network, there may be a large number of slaves within a cell, and so it is not feasible for the master to speculatively broadcast specific operating parameters to unconnected slaves. This results in a serious problem that a slave may be unable to associate with the master, even though communication would have been subsequently viable using the specific operating parameters.

The generic operating parameters are determined based on the worst case pixel within the supposed coverage area of the master. Therefore, a more conservative model for estimating the coverage area will result in more conservative generic operating parameters, especially as the



number of pixels in the coverage area increases with the square of the estimated range of the master.

The method for determining the coverage area of the WS master is described in Annex 3 of the consultation document. The coverage radius is calculated by taking the downlink link budget and converting it into a distance using the Extended Hata model. In effect, this approach corresponds to assuming that there is 50% probability of a slave at this distance from the master receiving the downlink signal at the sensitivity level of the slave's receiver. This is because the calculation is using the median value of the log-normal distribution.

We believe that a 50% probability for a slave at the cell edge to receive the master is not representative of a viable commercial network deployment, which must have a higher density of masters to ensure adequate overall coverage. We suggest that a 90% value is more representative for deriving the cell radius, as it is done for cellular systems like GSM. This assumes that slaves will connect to the master from which they receive the strongest downlink signal, which is a reasonable assumption as this will allow the slave to communicate more robustly and potentially at higher data rate with lower average power consumption.

The following figure shows the modelled cell radius as a function of the master transmit power, using the expected sensitivity of the Weightless downlink. It can be seen that moving from 50% coverage to 90% coverage makes a significant difference to the modelled cell radius. For example, at 32 dBm EIRP the cell radius for 50% coverage is twice as big as for 90%. The lower cell radius given by the 90% coverage metric is far more typical of the expected cell radius in the sense of expected basestation density for a real deployment. The benefit of using the 90% metric is that it is less likely that the transmit power from a slave device will be artificially limited by a pixel that is outside the realistic coverage area of the master.





In summary, we propose that a less conservative approach is taken to estimating the radius of the master coverage area. Our suggestion is to use a higher percentile (for example, 90%) for the proportion of WS slaves that can communicate at the cell edge, which is more representative of the basestation density in a realistic cellular deployment. An alternative approach would be to allow the intended coverage area of a WS master to be declared within the WSDB by taking account of the locations of neighbouring masters.

4. Indoor classification of type B devices

Clause 4.94 of the consultation document indicates that any type B device is assumed to be outdoors if its height is less than 2 metres. This means that any indoor type B device that is at a lower height cannot benefit from the nominal building penetration loss of 7 dB when estimating the coupling gains. This problem arises because the indoor status of the device is not included in the Device Parameters, and instead the height of the device has been used as a proxy.

Unfortunately, there are many M2M devices that will be at lower heights than 2 metres but are known to be indoors. One example would be a sensor in a soap dispenser that transmits a message to the basestation when the soap needs refilling. In fact, many indoor sensors are likely to be at lower heights than 2 metres.

We propose that whether a type B device is indoors or outdoors should be included in the Device Parameters. This would allow the building penetration loss to be included in the coupling gain calculation for indoor devices. Furthermore, we propose that generic operating parameters for both indoor and outdoor slaves are calculated (and broadcast) by the master, such that an indoor slave can use the indoor generic operating parameters.

This inclusion of the indoor status of a slave within its Device Parameters would only be allowed for type B devices that cannot reasonably be moved into an outdoor location, either as a result of physical attachment to the indoor location, or through a trusted installation process.