BEIRG
BRITISH ENTERTAINMENT INDUSTRY RADIO GROUP

Ofcom Consultation

British Entertainment Industry Radio Group (BEIRG)

TV White Spaces: Approach to Coexistence - Response

Date: December 2013

Contact Details:

Jeremy Burton
Ranelagh International Ltd on behalf of the BEIRG Steering Committee
One Ranelagh Road
Westminster
London SW1V 3EX

Tel: 020 7828 1603

Email: jeremy.burton@ranelagh-intl.com

TV White Spaces:
Approach to Coexistence
British Entertainment Industry Radio Group Response

BEIRG's response to this consultation consists of viewpoints, technical input and feedback from many people in the PMSE industry, which, after much discussion and cooperation, we have formulated into this document. Since BEIRG was formed in 2003 it has always sought to work with Ofcom in a collaborative manner, and since the introduction of the BEIRG Steering Group in 2006, we have generally had a very good and considered working relationship with the regulator. However there have been times, and this sadly is one of them, when our views on issues are clearly far apart. In situations such as these it is our responsibility to our industry, and the people we work for, to ensure that we raise our concerns as robustly as possible, where we deem it to be necessary. BEIRG remains committed to working in a collaborative and interactive manner with Ofcom in order to resolve and progress any issues which are raised by this consultation. We strongly believe that we must work together to resolve these issues, in order that that the PMSE industry is not harmed any further than it already has been as a result of the first Digital Dividend.

Executive Summary

- The protection ratios proposed in this consultation as they relate to PMSE are wholly insufficient. If adopted in their current form, UK PMSE operations will be harmed.
- The conclusions drawn from many technical working group meetings, CEPT and trials have largely been ignored in order to facilitate a better 'business case' for WSD developers.
- Failure to adequately address the protection ratio issue will, as a consequence, harm the £36 billion per annum creative sector of the UK economy.
- BEIRG believes that the decision to allow the deployment of WSD was premature and should not have been taken until sufficient testing with realistic numbers and types of WSD had been undertaken.
- If future testing shows that coexistence is not possible, then WSD should not be allowed to deploy in TV White Space within 600m of PMSE use.
- The definition of 'harmful interference' needs to be re-evaluated and defined with regards to how it relates to PMSE operations.
- The 400 metre exclusion zones around PMSE venues should initially be mandatory until the real world effects of WSD deployment are better understood.
- Promises of what new technologies might be able to deliver should not be allowed to compromise existing services that are already delivering significant social, cultural and economic benefits to UK PLC.
- No WSD should be permitted to operate on any frequencies when they are located within a designated PMSE venue. The potential for the wrecking of performances or events will be too great.

Requirements of Programme Making and Special Events (PMSE) Sector

The British Entertainment Industry Radio Group (BEIRG) is extremely concerned that the deployment of White Space Devices (WSD) into UHF broadcast spectrum, through shared access, has the potential to severely compromise PMSE's operating environment. Interference-free spectrum is **crucial** to the successful operation of PMSE equipment. By allowing the deployment of White Space Devices, it is easy to envisage an environment being allowed to develop that causes increased and more frequent levels of interference that will adversely affect current, existing users of UHF spectrum. Allowing more RF energy to radiate in the band will, inevitably, impact negatively on existing spectrum users.

BEIRG strongly believes that the proposals laid out in this consultation document cannot be permitted to progress unchanged. The conclusions of five years' of work by ITU, CEPT and Ofcom's Technical Working Group with regard to the protection levels required for PMSE have been largely ignored, in favour of the WSD community's projections. We implore Ofcom to agree to a more realistic protection system as a result of this consultation process. Failure to address this issue will, BEIRG believes, seriously compromise the PMSE sector's ability to maintain, let alone grow, PMSE operations in the UHF broadcast band for the future. As a result, BEIRG believes that there would be a high probability of market failure for PMSE and the sectors it serves. This would negatively affect practically every UK citizen and consumer, and damage the creative industries that contribute £36 billion annually to the UK economy and provide 1.5 million jobs[1]. An appetite for innovation, whilst understandable and indeed admirable, should not be allowed to compromise the activities of an established, licensed user of UHF spectrum; especially a user that is fundamental to the processes that generate so much income for UK PLC – PMSE.

The PMSE industry requires a sufficient amount of high quality, interference-free spectrum. Without sufficient access to spectrum, the PMSE sector's ability to produce content for consumers will be, and increasingly is, becoming severely hindered, if not impossible. The economic and social importance of PMSE, and the creative industries which rely on it, is continually growing. Today, this sector contributes £36 billion annually to the UK economy, and is currently responsible for 1.5 million jobs, compared to an industry from which the UK business case is more or less entirely unknown - WSD. What does Ofcom perceive to be the **realistic** projections for revenue and jobs from the introduction of WSD? And, for how long, given the potential re-allocation of the 700 MHz band? It is essential that Ofcom recognises the role of PMSE in the UK economy and prevents any interference from WSD into PMSE usage, which poses a serious risk to the revenue generation of this sector and its exports for UK PLC. As interference affects PMSE content production at its live source, regardless of the delivery medium for that content, industry users and audiences will be directly affected and face a huge potential loss of earnings and damage to consumer reputation.

BEIRG is also concerned about the very large costs that the presence of WSD interference could entail, and who would be liable for these costs in the event of disruption to PMSE as a consequence of WSD operation. Potential interference also has significant implications for venues such as theatres, studios, arenas, stadiums and other venues being able to secure insurance for their productions. A failure to obtain insurance will inevitably result in a show not going ahead.

[1] UK Department for Culture, Media and Sport, *Creative Industries Economic Estimates Full Statistical Release*, 2011, pp.16-18. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/77959/Creative-Industries-Economic-Estimates-Report-2011-update.pdf.

BEIRG welcomes the acknowledgement that, "in some respects", PMSE is considered a fully-fledged incumbent user, and therefore it cannot be expected to tolerate interference from any additional users sharing their legally licensed spectrum. If demand for PMSE or Digital Terrestrial Television DTT exists, it must always take precedence and be served before WSD or other proposed shared user requirements, in a similar fashion to the management necessitated by the London 2012 Olympics. The images and audio generated by PMSE, and broadcast globally, formed the foundation of this event whose legacy has been estimated to be worth more than £40 billion[2]. The potential disaster that interference during the Games could have wrought is unthinkable. What probability of interference did Ofcom accept for this event? Such a possibility in the future must not be allowed to take place as a side-effect of the introduction of WSD.

With the 700 MHz band under threat of clearance, there is concern within the PMSE industry that **there will not be sufficient TV white space remaining for PMSE to operate alongside DTT**. In some parts of the country, following any potential clearance of the 700 MHz band, it is likely that there will be no available white space left at all. We urge Ofcom to consider this possibility as part of its future planning, and we repeat our previous calls for Ofcom to designate a long-term, exclusive home in which audio PMSE (i.e. radio mics, IEMs and similar devices) can operate, free from interference.

Interference

BEIRG would like reassurance from Ofcom that it is prepared to act decisively to prevent any interference which may be incurred in the event that WSD are introduced. We note Ofcom's proposed objective of ensuring a low probability of harmful interference to other services in and adjacent to the UHF TV band, but urge Ofcom to ensure that there will be no possibility of 'harmful interference' to PMSE operators.

BEIRG is particularly concerned with Ofcom's definition of the term "harmful interference", and how this relates to the PMSE sector. The perceived audio quality of a production is the bedrock of any content. As such, in any production uninterrupted audio is **absolutely critical**. It follows that any interference experienced that causes a wireless audio failure has severe consequences for both the production and the audience alike. As far as the PMSE industry is concerned, **any interference is harmful** and has the ability to cause serious problems within our sector and beyond. Just a single incident of problems being encountered by PMSE users as a consequence of WSD, such as the cancellation of even a single performance of a major West End production due to excessive interference, will have large repercussions not only for PMSE, but for the whole white space industry, as the risks of local overcrowded spectrum become apparent. BEIRG urges Ofcom to clearly define this term, allocating specific dB numbers to interference levels, taking into account the noise floor, determining what level of interference is too great, and then adhering to this defined level throughout its testing and in any future implementation of WSD. Furthermore, we urge Ofcom to introduce and maintain **buffer zones in adjacent TV channels for any given PMSE allocation**, to protect those PMSE services.

Additionally, there are concerns over whether the introduction of WSD will provide sufficient value to taxpayers, when weighed up against expenditure on proposed database management by Ofcom, the threat

[2] UK Department for Culture, Media and Sport, *Report 5: Post-Games Evaluation - Meta-Evaluation of the Impacts and Legacy of the London 2012 Olympic Games and Paralympic Games*, 2013, p.5. Available at: https://www.gov.uk/government/news/olympic-games-legacy-boosts-economy-by-billions.

of damaging interference and potential compensation costs to disrupted industries. It is vital that the operation of the UK creative industries sector is not compromised by any avoidable, harmful interference.

PMSE equipment is used at the very start of the production chain; therefore any interference experienced by this equipment destroys not only the performance or event, but also any downstream revenue generation**.** For many PMSE users such as theatres, live TV broadcasts, live music and large political and industrial events, the presence of interference from unlicensed users, even if only for a short period of time, will be **disastrous**. BEIRG urges Ofcom to work to mitigate all interference from WSD to other services, and prevent any shared agreement that will impact on PMSE use. Any mitigation measures introduced, however, must not form an additional burden on PMSE users.

The Introduction of WSD

BEIRG believes that a phased introduction of WSD, using a cautionary approach and generous exclusion zones, is both necessary and reasonable to help accurately forecast what problems will develop. There is a risk that an initial full-scale introduction of WSD will be a step too far, and cause unexpected problems. We therefore acknowledge Ofcom's intention to err on the side of caution in its approach, but note that much more needs to be done on top of current plans for WSD introduction, and request that a gradual launch of WSD is incorporated into this plan. Only very limited testing of WSD has taken place to date, and we do not yet know the effects on the noise floor of large numbers of WSD operating simultaneously, other than the prediction that the noise floor will rise, or indeed the potential for WSD to interfere with other WSD. Ofcom has not satisfactorily considered this possibility, and the very small-scale trials that have taken place, and are currently planned for, will not demonstrate this.

BEIRG recommends that Ofcom only initially allows low levels of WSD to commence operation, using exclusion zones, as part of this very gradual model of introduction, before conducting extensive checks to ensure that no harmful interference is being experienced by PMSE or other industries. BEIRG believes that WSD should not be allowed to operate using high powers (up to 4 Watts) from the beginning of their introduction. Work can then be carried out to eradicate any interference which is present. The risks of interference due to overload from high power operation are not known, and have not been tested. Any tests or pilot schemes carried at lower power will not be able to test all the interference mechanisms, and Ofcom needs to understand and factor this in to its plans. Until it can be clearly shown that existing PMSE and broadcast users of spectrum, and consumers, will be entirely protected from harmful interference or disruption, and a safe balance can be struck, further WSD should not be introduced into spectrum.

White space is a limited resource and its quantity varies by location, especially in places such as Edinburgh, Liverpool and Malvern, and must not be exploited to the detriment of existing users and citizens. This will worsen with the introduction of WSD, as urban areas will become hotspots for WSD as well as PMSE. There is a delicate tightrope to be walked in this respect. BEIRG recognises WSD as an experiment in spectrum management, and can foresee that using a database to allow for remote control of devices could offer advantages to both administrators and users. However, by allowing the introduction of WSD into the UHF TV band, there is also a clear danger that WSD will impact industries vital to the social, cultural and economic wellbeing of the UK, and negatively affect the benefits received by UK citizens. Given the current lack of appetite in other European countries towards the deployment of WSD, these negative effects would be felt by UK citizens only. An additional concern is the possible high power use of WSD in rural areas; any such use

must also ensure no interference to PMSE or other operations. BEIRG is also concerned about the risk of aggregate interference, syncing of databases, and the effect of inter-WSD interference spilling into PMSE through increased intermodulation, and seeks Ofcom's reassurances that it will be able to protect PMSE from these and any other potential problems.

Whilst BEIRG would prefer not to see any WSD operating in TV white space, we recognise that the current direction of travel is towards a dynamic shared spectrum access model. In this scenario, and as part of any introduction of WSD to UHF TV spectrum, there should be clear lines of accountability. If the audio portion of a major concert or sporting event is ruined by interference from WSD, and this results in cancellation of the event, someone must be held accountable and face the financial consequences of this happening. A process should be in place whereby accountability can be clearly apportioned. This should not be the producer of the event – the polluter should pay. Were producers to be blamed for any WSD interference, a situation would very quickly arise where shows could no longer get insurance to hold a production. This would be disastrous for the industry, which would be all but halted as a consequence. While it may be impractical to target the individual responsible for operating the devices, in line with the Wireless Telegraphy Act, BEIRG believes that ultimately it should be the legal responsibility of the database operator to accept responsibility and the financial burden of any and all consequential loss.

Protections for PMSE

BEIRG also has concerns that there appears to be no planned control of the number and type of WSD operating on the same frequencies at the same location. Interference generated by competing WSD will cause intermodulation products and a rise in the noise floor which can and will impact on other users. BEIRG recommends that Ofcom introduce clear protection for all venues utilising PMSE, through the use of exclusion zones. Tests have proven that a zone of at least 400m around venues, at all frequencies, would be required to guarantee protection for our sector, the proposed 14m is a wholly inadequate exclusion distance. Without this, the potential threat of interference from WSD will mean that some shows simply will not be able to secure appropriate insurance, causing significant damage to the industry.

However, it must also be acknowledged that there is a difficulty in identifying all 'venues'. Venues are not purely fixed locations, such as theatres, but should be defined as any site at which PMSE is operating. This can vary hugely, both geographically and temporally, and can include yearly or one off sporting or cultural events (such as the Olympic Games, golf tournaments, or marathons), as well as live news events, which cannot be planned for. For example, during the Vauxhall helicopter crash of 16th January 2013, news broadcasters found that they were unable to make use of sufficient spectrum on the scene to broadcast live. As this took place in an urban environment without any WSD operating, the potential difficulty for future PMSE operation in a climate where WSD are active, and spectrum is even scarcer, is not hard to imagine. In these instances, Ofcom must seek to provide some means to instantly protect PMSE from WSD interference. Under current proposals, the database will update every 15 minutes, which from our perspective is unacceptable. This is too long a time for PMSE operators to wait on occasions when instantaneous access to interference-free spectrum is required.

More specifically, Ofcom needs to provide further information on whether a PMSE user suffering interference from a WSD will be allowed to change frequency without paying an additional licence fee or giving long-term notice. BEIRG is concerned that many PMSE users will experience WSD interference and be

forced to change their frequencies in order to keep an event going. However, the nearer it comes to 'show time', the less likely it will be that a user will be able to report a problem before switching.

In the presence of WSD, if a radio mic or IEM user were to change frequency without notice, they would be more likely to experience further problems as the databases would not know that the PMSE user is temporarily operating on another frequency. The nature of the PMSE sector means that users are going to be particularly engaged with their work on the day of a show. Therefore, they are not necessarily going to report any interference at the time it takes place. Likewise, due to the nature of touring productions, PMSE professionals would struggle to find the time to report issues that they might have experienced during a previous evening's performance. This could potentially lead to a scenario where Ofcom falsely believe that there are no (or very few) interference issues introduced as a consequence of WSD, as they are not comprehensively reported. It is therefore vital that the database manager is able to react in real-time to any WSD interference introduced to UHF TV spectrum that is conflicting with PMSE operations. BEIRG expects that a 'kill switch', as discussed previously, taking effect in a matter of seconds from being notified of interference, could provide a more reasonable level of protection to other spectrum users, such as PMSE, but this seems to be absent from current proposals.

WSD Testing

The PMSE industry has actively engaged with ITU, CEPT, Ofcom and the Cambridge White Spaces Consortium over the past five years, and continues to work with Ofcom on this area. Our concern to date is that only one brand of WSD (Neul) has been trialled, with only three units tested at any one time. No mass testing has yet taken place, as it has been limited by the numbers of WSD available. Ofcom must not base its future WSD policy on the results of testing based on one single type of device, when a range of devices will become available, with varying power levels. This cannot be considered 'real-world' testing.

BEIRG also has concerns as to the nature and type of WSD equipment that will find its way into the market. A recent surveillance campaign by the Group of Administrative Co-operation Under R&TTE Directive into WLAN 5 GHz equipment found the following;

> ***"1. Compliance with some DFS (Dynamic Frequency Selection) requirements***
> *Campaign showed that almost all (61 of 64) checked WLANs had implemented DFS function but on the other hand in twenty two (22) cases (34%) the device's firmware allows the end-user to switch off the DFS function. This is not in line with the requirement 4.9.2 of harmonized standard EN 301 893 version 1.5.1, 4.10.2 of harmonized standard EN 301 893 version 1.6.1. or 1.7.1 (5.15-5.35 GHz and 5.47-5.725 GHz) or requirement 4.6.1 of the harmonized standard EN 302 502 (5.725 – 5.875 GHz). In some cases information how to deactivate DFS function was included in device's user manual or presented on manufacturer's web site. In thirty eight (38) cases DFS function could be indirectly deactivated by changing the device's region of use."*[3]

If WSD devices are to be allowed into the market with a similar level of 'flexibility' then the results will be disastrous for the PMSE sector and possibly also for DTT reception. This is what BEIRG refers to as the 'jailbreak' scenario and needs serious consideration from stakeholders and regulators alike. There is also still

[3] Group of Administrative Co-operation Under the R&TTE Directive, *Report on the 5th Joint Cross-Border R&TTE Market Surveillance Campaign on WLAN 5 GHz (Draft V 1.7)*, 2013, p. 3. Document is available on request.

a need to further investigate the potential effect that WSD have on interference levels amongst other users and to take this into account as part of future spectrum management and planning. BEIRG welcomes the planned additional tests, and hopes that these will prove sufficient to fully understand the implications and effect on other users that would arise from allowing unlicensed WSD to operate. These will help to clarify some of the data that has been presented in this consultation, which BEIRG disagrees with. For example, the proposed received wanted signal power for wireless microphones of -65 dBm, which was pulled from the Chester '97 Annex 5 is not appropriate, as it represents an out of date and inaccurate estimation.

It remains difficult for the PMSE industry (and other sectors) to fully estimate the impact of WSD due to a lack of data from Ofcom. BEIRG has some concerns over the technical figures that have been set out by Ofcom in its technical report accompanying this consultation. Consequently, BEIRG believes that there is still a need for detailed, accurate testing to be conducted, using real world locations such as theatres, arenas, stadiums, etc., and carried out by technically competent individuals at appropriate testing sites, such as at the Technical Measurement Centre in Baldock. BEIRG and the PMSE industry remain keen to assist Ofcom in conducting these investigations into the effects of WSD on UHF TV spectrum and on PMSE, and will work with Ofcom to provide opportunities for real world testing alongside PMSE devices. This should provide Ofcom with clear information about the PMSE industry and its requirements, and help to clarify the potential impact WSD could have on the UK creative industries. However, if as a result of the testing program it becomes apparent that coexistence between PMSE and WSD is not going to be possible, then Ofcom must have the strength of character as an organisation to reverse its, what some might believe premature, decision to allow WSD to be deployed in TV White Space or, at the very least, ensure exclusion zones of 600 metres around designated PMSE venues. Taking a decision to allow the deployment of WSD before knowing what the full ramifications of that deployment might be, from the perspective of BEIRG, is the wrong way around.

Conclusion

BEIRG recognises that the development of new technologies is crucial to UK plc. Indeed, the PMSE sector supports such innovation; it has been the life blood of our industry for decades. But innovation cannot come at the risk of disrupting or damaging existing industries, especially ones which make a unique and crucial economic, cultural and social contribution to the UK and its exports.

BEIRG stands ready to work with Ofcom to ensure that the potential benefits of WSD are exploited whilst our industry is fully protected from interference. Ofcom in turn must show an understanding that any interference to PMSE is harmful and take appropriate steps to reassure the industry about accountability for any such interference.

We are keen to assist in implementing 'real life' testing in theatres or other appropriate venues, but urge Ofcom to implement a slow, measured and phased introduction of WSD. This should include the use of 400m exclusion zones around all PMSE venues.

Finally, the proposed introduction of WSD again underlines the importance of Ofcom working in a collaborative manner with BEIRG and others to secure a long term home for the PMSE sector, through which the industry has access to a sufficient quality and quantity of spectrum.

British Entertainment Industry Radio Group

The British Entertainment Industry Radio Group (BEIRG) is an independent, not-for-profit organisation that works for the benefit of all those who produce, distribute and ultimately consume content made using radio spectrum in the UK. Venues and productions that depend on radio spectrum include TV, film, sport, theatre, churches, schools, live music, newsgathering, political and corporate events, and many others. BEIRG campaigns for the maintenance of 'Programme Making and Special Events' (PMSE) access to sufficient quantity of interference-free spectrum for use by wireless production tools such as wireless microphones and wireless in-ear monitor (IEM) systems.

As well as being vital in producing live content, wireless PMSE technologies play a key role in helping to improve security and safety levels within the entertainment industry and other sectors. Their benefits include improving the management of electrical safety, the reduction of noise levels, the development of safety in communications and reducing trip hazards as well as providing an essential tool for the security orientated services. Wireless equipment and the spectrum it operates in are now crucial to the British entertainment industry.

BEIRG is a member of the Association of Professional Wireless Production Technologies (APWPT)[4], which promotes on an international level the efficient and demand-driven provision and use of production frequencies for professional event productions, as well as safeguarding such production frequencies for the users on the long run.

[4] http://www.apwpt.org/

ANNEX

TV White Spaces:
Approach to Coexistence
British Entertainment Industry Radio Group - Technical Analysis

We do not believe that proper consideration has been given to the potentially disastrous effects of intermodulation with regard to PMSE and WSD. In particular, we do not believe that any consideration has been given to the potential for reverse transmitter intermodulation between multiple WSD – slaves or masters – operating in proximity to each other, whether these be operating co-channel, adjacent channel or on channels with some degree of frequency separation. Since they could be under the control of separate WSDB they will be uncoordinated and the resulting intermodulation products we believe represent a serious interference risk to other services. In the case where a WSD were permitted to transmit close to or inside a PMSE venue then there is also the very considerable risk of reverse intermodulation occurring between WSD and PMSE transmitters. Since it will not be possible to take these effects into consideration and calculate their relationship to PMSE assignments we believe that the only way in which PMSE can be protected from WSD interference is by the implementation of WSD exclusion zones of a minimum of 400 metres around PMSE venues.

Question T8: Do you have any comments on our approach for calculating WSD emission limits, as expressed in Equation (5.2), in relation to PMSE coexistence calculations?

We do not agree that it is inappropriate to use the interferer-to-noise approach. Whilst it may be true that in some cases PMSE users do have to contend with significantly raised RF noise floors at some locations and events, due in part to the unwillingness or inability of regulators and other agencies to deal effectively with certain EMC issues, this is by no means always the case. Neither is it a situation which the industry is prepared to accept. There are many instances of PMSE equipment being operated at the extremes of its capabilities and operational range where the low noise figure of state-of-the-art receivers are exploited to the full. These proposals would dramatically undermine the work of many professional PMSE practitioners by arbitrarily elevating the risk of interference at random intervals. The squelch threshold, which is normally a user adjustable control to determine the signal voltage level required before the receiver un-mutes, of many modern wireless microphone receivers has a maximum setting considerably lower than -65dBm[5], this would not be practical if the noise floor was as elevated as is being implied. In practice users will adjust the squelch threshold of their receivers to the lowest possible setting which ensures that the receiver remains muted when the relevant transmitter is switched off whilst maximising the operating range when it is in use. Frequently this will result in a setting of 5µV (-93dBm in 50 ohms) or lower.

[5] For example the Sennheiser EM 3732 has a maximum squelch setting of 30µV, i.e. slightly less than -77dBm in a 50 ohm system.

Question T9: Do you have any comments on the PMSE wanted signal power levels that we propose in relation to coexistence calculations?

We cannot accept that there is any reason not to protect PMSE down to the sensitivity of the receivers. The proposed wanted signal levels do not take in to account the fading characteristics of typical PMSE operations at all. Protecting only down to the suggested wanted power of -65dBm for wireless microphones and IEMs for example would dramatically reduce the useful operating range of PMSE equipment. We cannot find any logic to the statement in 5.40, except to increase the availability of spectrum for WSD at the expense of existing PMSE activities.

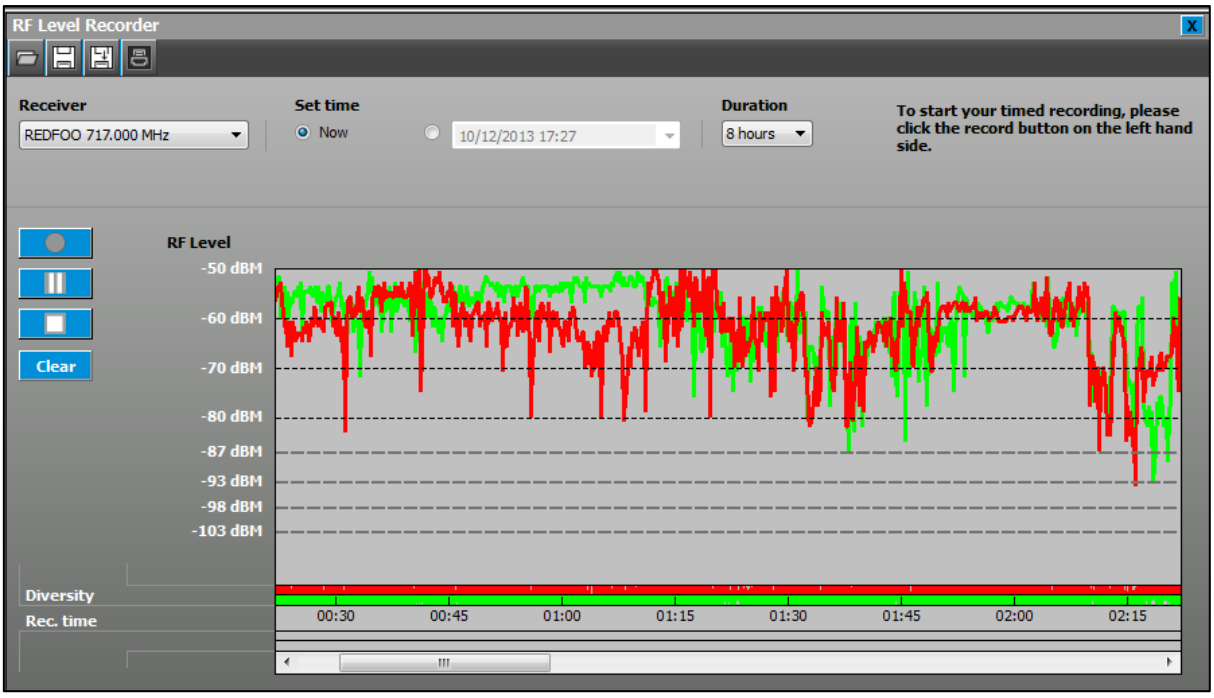

Figure 1 - Example of Radio Microphone Signal Fading – Red and Green traces show signal strength received at the two spaced diversity antennas over approximately two hours of operation.

In suggesting that the wanted power level for IEMs is the same as that for wireless microphones Ofcom have completely failed to take into account the much higher, by at least 20dB, wanted signal strength required for Stereo operation which is the mode in which the bulk of IEM systems are used.

In citing the "The Chester Agreement" as the source of wanted power levels no account has been taken of the fact that the wanted power levels for SAB/SAP in that document were also to be adjusted for frequency[6] from the figures provided which are all given for a single frequency of 650MHz, which results in approximately 4.5dB of variation across the available UHF range.

[6] European Conference of Postal and Telecommunications Administrations, *The Chester 1997 Multilateral Coordination Agreement relating to Technical Criteria, Coordination Principles and Procedures for the introduction of Terrestrial Digital Video Broadcasting (DVB-T)*, Chester, 25 July 1997, Annex 5, 2. Protection criteria for other services. Available at: http://www.archive.ero.dk/132D67A4-8815-48CB-B482-903844887DE3?frames=no&.

Question T10: Do you have any comments on our proposed approach for calculating coupling gains in relation to PMSE calculations?

> *"5.46 In deriving Equation (5.3) we have not accounted for any angular or polarisation discrimination at the transmitter or receiver antennas. This is because information regarding the orientations of the WSD and PMSE antennas will typically not be available. We acknowledge that ignoring antenna discrimination results in an over-estimation of the extent of interference. In practice, judicial positioning of PMSE receiver antennas can boost the PMSE signal by around 10 dB, while simultaneously suppressing the WSD signal by around 10 dB."*[7]

This statement is flawed and does not apply to the vast majority of PMSE use. Since the location of a potential interfering WSD, or multiple WSDs will most likely not be known to the PMSE users it is unlikely that they will be in a position to use the directional properties of wireless microphone receiving antennas as a mitigation against WSD interference – even where such directional antennas are available and appropriate to the needs of the PMSE application in question, which is far from being the universal case. Directional antennas can sometimes be used as mitigation against interference to PMSE receivers from distant DTT transmitters, but the locations of DTT transmitters are both known and fixed, they are not generally mobile, none of which may apply to future potential WSDs. Various types of portable PMSE receivers including IEM and talkback are unable to benefit from any form of directional receiving antennas as these receivers are generally attached to a person. Therefore we do not believe that ignoring antenna discrimination can be said to definitely over-estimate the extent of interference. If a WSD happens to be within the front beam angle of the directional antenna then the WSD signal will also benefit from the same 'boost' as any wanted PMSE signals originating within the front beam angle of the antenna. Only in the best case where the WSD happens to be off the back of the beam and the PMSE transmitter is in front of the antenna will there be any benefit since the front to back ratio of a directional antenna is usually considerably greater than the gain achieved in the front lobe. A typical log periodic commonly used in PMSE applications has only about 3dB of gain in the 90 degree wide the front lobe, but has a front to back ratio of about 10dB.

We note that in footnote 31 on page 65 it is explained that WSD will not be permitted to transmit inside PMSE venues. However it is not clear whether this will be simply for the case where a WSD would be co-channel with the PMSE users or for all possible TV channels. It is imperative that this is the case for all channels since the carefully calculated intermodulation environment, the planning of which is vital in order to avoid mutual interference in any multi-frequency PMSE system - anywhere that there are three or more UHF frequencies in use – will be totally destroyed by the introduction of additional UHF transmissions inside or adjacent to the PMSE venue.

It is inconsistent to state (Table 5.3) that 0dBi is a typical PMSE antenna gain when in para 5.46 it is claimed that PMSE can benefit from an alleged antenna gain of 10dB.

> *"5.49 The assumed value of the PMSE antenna gain is consistent with the value used for deriving the received wanted PMSE signal power."*[8]

We have already stated that we believe the figures for wanted received PMSE powers have been misinterpreted and therefore the statement in 5.49 is also invalid.

[7] Ofcom, *TV White Spaces: Approach to Coexistence - Technical Analysis*, 2013, p. 65.
[8] Ofcom, *TV White Spaces: Approach to Coexistence - Technical Analysis*, 2013, p. 66.

Question T11: Do you have any comments on our proposed approach for dealing with the uncertainty in the locations of WSDs in relation to PMSE calculations?

We do not believe that the approach takes into account the extended interference footprint of slave WSDs operating at or near the edge of a Master's coverage area. A Slave, or Slaves, operating at the same power level as its Master will extend the interference footprint to double the radius of the Master alone.

Question T12: Do you have any comments on our proposed approach for dealing with the uncertainty in the locations of PMSE receivers in relation to PMSE calculations?

No comments.

Question T13: Do you have any comments on our proposed approach for the derivation of WSD-PMSE coupling gains for non-geolocated slaves in relation to PMSE calculations?

> *"5.68 However, it is possible that certain slave WSD candidate locations might coincide with certain PMSE receiver candidate locations. This means that the WSD-PMSE separation d might be calculated as zero, implying a zero maximum permitted in-block EIRP spectral density PIB in every channel (since mG = +∞). Consequently, the coverage area of the master WSD would be completely sterilised and non-geolocated slave WSDs therein would not be permitted to radiate at all. In practice, the probability of such co-location is vanishingly small, as the slave WSD could be located anywhere within the coverage area of the master."*[9]

We do not understand why the fact that WSD sharing a location with PMSE would be prevented from transmitting is seen as a problem as this is, without doubt, the only way to fully protect PMSE from interference, as has been promised repeatedly during our engagement with Ofcom and the WSD community. The use of a default WSD-PMSE horizontal separation of 10 metres is extremely unrealistic and concerning. If a WSD is at the same location as a PMSE device then the horizontal (and or vertical) separation between a portable WSD and a PMSE receiving antenna could be effectively zero. Assuming that it is a minimum of 10m provides zero protection to PMSE. If in the future WSDs are to become as successful as their supporters would wish then they will be in every pocket and handbag meaning that they will be everywhere and their physical separation distance from PMSE equipment will be impossible to know or control.

The statement that "*In practice, the probability of such co-location is vanishingly small, as the slave WSD could be located anywhere within the coverage area of the master"* is particularly concerning since in the case where the PMSE venue is the largest concentration of population within the coverage area of a Master then the concentration of portable Slave devices within the venue would be extremely high as would the probability of their location being inside the venue. One does not have to try very hard to imagine a scenario where Master stations are positioned around the outside of the perimeter of a

[9] Ofcom, *TV White Spaces: Approach to Coexistence - Technical Analysis*, 2013, p. 71.

venue or event site to provide coverage to portable devices within the site, it is a situation which is extremely common with cellular base stations. The coverage area of a Master in this case may theoretically include large areas that are not within the venue, but this is of little consequence when the only Slave devices which will be connecting to it are being carried by the attendees at the events within the venue.

Question T14: Do you have any comments on our proposed protection ratios in relation to PMSE calculations?

The proposed protection ratios do not take account of the harmful interference potential of intermodulation between multiple transmissions. Simple consideration of ACLR will provide no protection from this highly damaging type of interference. As already stated above the carefully calculated intermodulation environment, the planning of which is vital to any multi-frequency PMSE system - anywhere that there are three or more UHF frequencies in use – will be totally destroyed by the introduction of additional UHF transmissions inside or adjacent to the PMSE venue with potentially catastrophic interference consequences for the PMSE services.

The protection radios for IEMs in particular do not appear to take into account Stereo operation which as mentioned above is the predominant mode of operation for IEM systems. Despite occupying the same 200kHz RF bandwidth as a radio microphone Stereo IEM operation involves a multiplex system and within the receivers the demodulation of a greater bandwidth of modulating signals[10] than mono operation which necessarily results in greater susceptibility to interference. Stereo operation is a vital element of the health and safety benefits to performers using IEMs in live production environments.

> *"5.72 We have undertaken a number of measurements to quantify the protection ratios relevant to different PMSE use cases. We have used a WSD signal based on the WiMAX standard for this purpose. The details of the measurement procedures and the post processing of the results are presented in Annex 5. We have characterised PMSE receiver failure as a 6 dB reduction in signal-to-noise and distortion ratio (SINAD)."*[11]

The use of SINAD as a method for determining 'failure' in this way has serious limitations. Although it has been used elsewhere such as in the Cambridge Trial[12] this was in spite of those limitations, driven by the need to get 'some data' where none existed, the method being accepted in desperation as the 'least worst' available option. We believe that there is a need for a new system of audio measurement which can be applied in order to quantify the effects of interference to high quality RF audio systems regardless of the mechanism by which the interference is caused. At present the only way to detect all types of effects of interference in audio PMSE is with the human ear. Many of the audible artefacts of interference to PMSE

[10] Baseband signals ranging up to 53kHz for Stereo MPX rather than 20kHz for a mono radio mic, or 15kHz for a stereo capable IEM operating in mono mode.

[11] Ofcom, *TV White Spaces: Approach to Coexistence - Technical Analysis*, 2013, p. 71.

[12] Cambridge Silicon Radio Limited, *Cambridge TV White Spaces Trial: PMSE Trial Repor*t, 2012. Available at: http://docbox.etsi.org/Etsi_Cenelec/PUBLIC%20FOLDER%20on%20DD/White%20Space/White%20Space%20Cambridge%20PMSE%20Trial.pdf.

audio equipment whilst obvious to a human observer will be undetectable or barely measurable using techniques such as SINAD, partly because the test signals used will themselves mask the interference until it is extremely severe. We are aware that this presents a considerable number of practical problems for scientific study and that it is therefore necessary to formulate a method which can be proven to match the identification of interference possible by the human ear and quantify the audio degradation resulting from that interference. There is a world of difference between loss of intelligibility in telephony and a reduction in audio quality due to interference in professional audio PMSE systems. **No 'harmful interference' in PMSE means 'no reduction in the quality of the signal transmission in any respect' in the presence of the potential interferer or interferers compared to the quality of the signal transmission that would exist in the absence of the potential interferer or interferers.**

To put this in perspective a test signal sourced from CD will have insufficient dynamic range since the best possible CD can only achieve 90dB of audio dynamic range whereas the best wireless microphones can manage 117dB, and even the lesser models achieve 100dB.

In the case of digital transmission systems harmful interference may be somewhat easier to quantify since there may be the possibility to measure error rates and compare them with and without interferers. In this sense the advantage of digital systems is clear, their failure modes are almost by definition binary in nature; it either works or it doesn't. However the vast bulk of audio PMSE equipment in production and in daily use is still analogue and is likely to remain so. For various reasons, which are outside the scope of this response, digital systems are unlikely ever to fully replace analogue systems in PMSE audio, though the balance between them will most probably shift more towards digital transmission systems over time. It is worth noting that whilst analogue wireless microphones and IEMs all use wide band FM transmission the digital wireless microphones which have emerged so far from various manufacturers all use different modulation and coding schemes. There are no digital IEM systems available at present. The carrier-to-noise or carrier-to-interference requirements of the digital wireless microphone systems are contrary to what some might expect; they are more demanding than their analogue counterparts. One big difference being that in the case of a digital wireless microphone some interference will be tolerated with no resulting audio degradation, but once a certain level of interference is reached the error correction and or error concealment systems are unable to cope and there is a total failure of the audio link. In the case of an analogue system the failure mode is quite different; a small amount of interference may produce no audio degradation. A slight increase in the level of RF noise or interference may result in a small amount of degradation in the transmitted audio. As the interference-to-carrier ratio worsens then the audio transmission quality also worsens and not necessarily in a linear manner. The point at which 'failure' is declared to have occurred therefore has a huge range of variable factors associated with it, hence the only comparison which can be universally accepted is between overall audio transmission quality in the absence of interference and in the presence of interference.

Question T15: Do you have any comments on our assessment that a margin for uncertainties in radio propagation is not necessary given the proposed parameters for derivation of coupling gains in relation to PMSE coexistence calculations?

Anything which reduces the levels of protection to PMSE is unacceptable. Whilst there are obvious benefits for would be WSD there are no benefits to PMSE from an increased probability of interference. We remain

to be convinced that this approach can be shown in any way to be increasing the levels of protection to PMSE from WSD therefore we are not in favour of this approach.

Question T16: Do you have any comments on our proposed WSD emission limits in relation to PMSE use in channel 38?

Whilst controlling the emission limits in the channels adjacent to channel 38 is a positive step in attempting to minimise the probability of interference to PMSE and radio astronomy use of channel 38 we do not believe that it will be completely successful in eliminating harmful interference to those services from WSD.

In common with PMSE use of the UHF White Space, channel 38 is able to and does support multi-channel PMSE operations. In order to achieve this however, careful planning of intermodulation within channel 38 and with regard to other UHF transmissions is required in order to avoid mutual interference. The industry has evolved a number of strategies to cope with situations where multiple PMSE Channel 38 licensees operate in close proximity to each other.

As stated above, we do not believe that proper consideration has been given to the potentially disastrous effects of intermodulation with regard to PMSE and WSD. In particular we do not believe that any consideration has been given to the potential for reverse transmitter intermodulation between multiple WSD – slaves or masters – operating in proximity to each other, whether these be operating co-channel, adjacent channel or on channels with some degree of frequency separation. Since they could be under the control of separate WSDB they will be uncoordinated and the resulting intermodulation products we believe represent a serious interference risk to other services. Since the location of channel 38 PMSE users is unknown even exclusion zones are impractical. We do not therefore believe that it will be possible to fully protect PMSE operations in channel 38 from WSD interference.