

Digital Dividend: Cognitive Access

British Entertainment Industry Radio Group (BEIRG)

Response to consultation on licence-exempting cognitive devices using interleaved spectrum

Date: Friday 1st May 2009

Contact Details:

**Alun Rees
Ranelagh International Ltd on behalf of the BEIRG Steering Committee
One Ranelagh Road
Westminster
London SW1V 3EX**

Tel: 020 7828 1603

Introduction

Whilst we accept that, in principle, any device which definitively does not and will not cause any interference to licensed users should be able to use the same spectrum as those licensed users on a licence-exempt basis, we have severe reservations that any form of cognitive device will be able to meet these conditions. Cognitive devices are unproven and have failed repeatedly to detect and avoid interfering with PMSE, specifically wireless microphones, as evidenced by the tests carried out by the FCC.

Ofcom have explored what services cognitive devices might potentially offer, but only if deployed in the cleared (and not interleaved) spectrum¹. However, as far as we are aware, the manufacturers have not said what their use will be. On the other hand, incumbent PMSE applications such as wireless microphones have been deployed in the interleaved spectrum for decades and are essential for the production of live and recorded entertainment including the Performing Arts, Broadcasting, News Gathering, Film and Independent Production, Corporate Events, Concerts, Night Venues and Sports Events.

Any interference with PMSE applications will disrupt content production at its live source. As a consequence of this interference, the value and benefits this content would normally generate through its consumption via a variety of media and exposure to a much wider audience will be significantly reduced or lost at the beginning of the value chain. Moreover, any interference, however short in duration and irrespective of whether it is transient, to PMSE applications is harmful, particularly for live professional performances. No audio distortions or disruptions are acceptable to contemporary audiences.

Ofcom must take these points into account when considering whether cognitive access to the interleaved spectrum should be permitted at all. Based on current evidence, it will risk devastating live and recorded content production without guaranteeing any discernible benefits to citizens and consumers of the UK. Further risks are that (1) devices that do not meet the requisite technical specifications may be used in the UK nonetheless or (2) the devices could be adjusted² to remove the interference-protection functions.

In light of these risks, we believe that Ofcom must consider restricting cognitive devices to bands where there are no incumbent PMSE applications; whilst we do not believe (and indeed current evidence suggests) that they can coexist with existing radiomicrophones and other short-range licensed wireless devices, deployment in alternative available bands will not preclude future coexistence with new technologies or applications.

If Ofcom do insist on allowing cognitive access to the interleaved spectrum, they should not squander the benefits of PMSE and DTT to UK citizens and consumers by setting weak interference prevention standards and allowing a flood of inexpensive devices to enter the band that will likely interfere not only with incumbent services, but also with each other.

We note that this consultation applies only to the interleaved spectrum and not channel 69 or any replacement bands. Cognitive devices must not be able to be deployed in channel 38 anywhere in the UK. To ensure this, they must not be able to operate on these frequencies (and corresponding manufacturing specifications implemented).

Responses to questions

Question 6. Do you agree that the reference receive level for wireless microphones should be -67 dBm?

No. The reference receive level for wireless microphones should be -95 dBm.

¹ See <http://ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> A5.11

² In a way analogous to mobile phones being 'unlocked'

Ofcom's objective is to 'ensure that cognitive devices will not cause harmful interference to licensed uses of the same spectrum, particularly DTT and PMSE'³. The parameters for licence-exempt cognitive devices using interleaved spectrum must protect **all** licensed users and hence all existing PMSE applications and technologies.

The signal levels that receivers are '**typically operated at**... in order to ensure a high quality link'⁴ (i.e. above -67 dBm, as measured by ERA) should not constitute the reference receive level for wireless microphones because this will not ensure protection of all existing PMSE applications and technologies, particularly as it does not take into account all circumstances and conditions that they operate in.

A typical professional wireless system leaves the factory with the squelch threshold set at -95 dBm. Due to multipath, one would not want to assume this is an adequate level for operation, but during operation it is quite normal to see fading on the order of 30 dB or more. Thus (and as indicated by ERA's measurements) a good wireless system designer would probably want to design the system to achieve a received signal level of -67 dBm at the receiver input in order to provide an adequate fade margin. However, this does not imply that the signal will always be at this level. The level to be protected should be in the vicinity of the -95 dBm value unless the PMSE user is willing to accept shortened range and reduced performance.

We question why ERA measured the sensitivity of a 'range' of wireless microphones and why Ofcom believe that the 'average' sensitivity at the input of the wireless microphone receiver is relevant when considering what the reference receive level should be. Using the average sensitivity as the reference receive level risks interference to those that are more sensitive⁵ than the average.

If Ofcom are to ensure protection to all existing wireless microphones then the reference receive level should be the greatest sensitivity at the input of any wireless microphone receiver. As far as we are aware, this is -95 dBm (i.e. interference to the receiver is possible anywhere up to this sensitivity).

Question 7. Do you agree with an additional margin of 59 dB for wireless microphones?

Due to the unreliability of additional margins in ensuring that no harmful interference to wireless microphones occurs, the additional margin of 59 dB would be acceptable provided that network sensing⁶ is also a compulsory requirement in order to help mitigate hidden terminal problems.

The additional margin is an 'estimate of the difference in signal level that might be caused by the hidden terminal problem'⁷ which is 'added on' to the reference receive level to determine the overall sensitivity requirement in order to mitigate the hidden terminal problem.

As Ofcom appreciate, one must not assume reciprocity between the path from the wireless microphone and the license-exempt device. That would be true if a wireless microphone system worked in the same way their devices do; they do not. The license-exempt device detects a signal from a wireless microphone **transmitter**, but what matters to the wireless microphone system is the D/U⁸ ratio at the wireless microphone **receiver**, which is necessarily at a different location. Therefore, it is perfectly possible for a license-exempt device to fail to detect the wireless microphone signal and yet interfere with the receiver, because they are not at the same place. This is why network sensing⁹ is important for overcoming hidden-node problems caused by multipath

³ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 2.6

⁴ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 5.29

⁵ By definition, many wireless microphone receivers will be more sensitive than the average

⁶ All devices in a "network" (2 or more devices that are interconnected) must be required to (a) undertake detection/sensing as per the parameters agreed and (b) share sensing data to mitigate against hidden terminal problems.

⁷ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 4.5

⁸ Desired/Unwanted

⁹ See footnote 4

and shadowing. The requirement for network sensing is explained in more detail below.

As Ofcom have explained, determining the additional margin, is 'much more problematic (than determining the sensitivity of a device)'¹⁰:

- 'It is impossible to measure all situations'¹¹
- 'The best that can be achieved is to either model or measure a set of locations selected as carefully as possible to be representative and then assume that the results will generally be valid.'¹²
- 'The measurements themselves will be probabilistic'¹³
- 'values may...have substantial error bars associated with them'¹⁴
- 'There is a further problem due to use of adjacent channels...For many devices, including most DTT receivers, a strong signal on a channel adjacent to the one to which they are tuned can also cause interference.'¹⁵

The lack of reliability of the calculated additional margin, which Ofcom acknowledge, demonstrates why network sensing must also be a compulsory requirement in order to help mitigate hidden terminal problems.

In addition, the required detection threshold for license-exempt devices needs to be based not only on the required D/U ratio at the wireless microphone receiver, but also on the transmission power of the device relative to that of the wireless microphone. As Ofcom appreciate (and as discussed in the consultation), body absorption and shadowing can reduce the power of a wireless microphone significantly. Although body pack transmitters are permitted to operate with higher power (50 mW vs. 10 mW) and generally have more efficient antennas than handheld transmitters, they usually suffer from greater body attenuation¹⁶, with the result that the effective radiated power in actual use is rather similar and is on the order of 1-5 mW typically for either type. A license-exempt device that is allowed to transmit with an effective radiated power of 100 mW would be some 20-100 times stronger.

In conclusion, a low sensing threshold in the absence of any other qualifying requirements does not necessarily equate to adequate interference protection in the real world; all devices in a "network" (2 or more devices that are interconnected) must therefore be required to (a) undertake detection/sensing as per the parameters agreed and (b) share sensing data to mitigate against hidden terminal problems¹⁷

Question 8. Do you agree with a sensitivity requirement for -126 dB (in a 200 kHz channel) for wireless microphones?

Based on the method that Ofcom has used to determine the sensitivity requirement and that the reference receive level for wireless microphones should be -95 dBm rather than -67 dBm, the sensitivity requirement would theoretically be $-95 - 59 = -154$ dBm. However, we accept that -154 dBm is not technically feasible on any level, as it is far below the thermal noise level on that bandwidth-- $kTB = -154$ dBm/sqrt(Hz).

Taking this into account, we believe that a sensitivity requirement of -126 dB would be more realistic, provided that

1. Devices are tested and achieve that level under conditions that simulate a real-world operational working environment¹⁸.

¹⁰ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 4.7

¹¹ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 4.7

¹² <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 4.7

¹³ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 4.7

¹⁴ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 4.7

¹⁵ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 4.8

¹⁶ Body attenuation is variable and is dependent on many factors, including size of the individual

¹⁷ FCC rules require this

¹⁸ It must not be assumed that if a cognitive device achieves the -126 dB requirement in a test chamber (i.e. indoors with

2. Ofcom undertake testing of all models of prototype and consumer cognitive devices to ensure that they do not cause harmful interference to wireless microphones and all other existing PMSE applications that use the interleaved spectrum on a licensed basis. This should include consulting fully with PMSE stakeholders, including BEIRG, when drafting the test standards and ensuring that the standards are available for public scrutiny and comment prior to approval and implementation.
3. PMSE stakeholders, including BEIRG, are involved in the testing process to verify that harmful interference is not caused.
4. Devices are not sold on the UK market on the basis of self-certification.
5. All cognitive devices in a “network” (2 or more devices that are interconnected) are required to share sensing data to mitigate against hidden terminal problems¹⁹.
6. All cognitive devices measure their location and make use of the geolocation database to determine which channels they can use at that location²⁰.
7. Ofcom take necessary and appropriate action to ensure that cognitive devices do not in practice interfere with PMSE applications. This will include:
 - a. undertaking policing and enforcement to ensure that requisite specifications of cognitive devices in use in the UK (including those imported from overseas) are complied with; and
 - b. retaining the capability to use the database for spectrum management purposes²¹.

Question 9. Do you agree with a maximum transmit power level in line with that for DTT? Are there likely to be any issues associated with front end overload?

Broadly, yes, a power level of 13 dBm on adjacent channels should be compatible with wireless microphones provided that spectrum sensing works effectively.

However, if the power levels were to be further increased, then spectrum sensing becomes impractical because the transmit power disparity between the microphone and the cognitive device becomes too great. It is also worth noting that these power levels would be problematic for some existing protocols.

Question 12. Is it likely that mobile television will be deployed in the interleaved spectrum? If so, would it be proportionate to provide full protection from cognitive access?

No service other than PMSE, including mobile television, must be permitted to be deployed in the interleaved spectrum unless it is proven that this would not prevent the band manager from meeting reasonable PMSE demand as per its licence obligations. The band manager’s licence obligations are still under discussion. Please see our response to the consultation on the band manager’s institutional arrangements for further views on this²².

Question 13. Should we take cooperative detection into account now, or await further developments and consult further as the means for its deployment become clearer?

Please see answers to questions 7 and 8

Geolocation databases

lower background RF levels) then this ability will automatically be replicated in practice¹⁸. Therefore, only if cognitive devices meet the -126 dB sensitivity requirement in a real-world scenario along with all other performance requirements (time between sensing, geolocation, power levels etc) should it be permitted access to interleaved spectrum in the UK (and the UK market). In order to ensure this, rigorous test standards and procedures will be required.

¹⁹ Reasons explained in response to question 7

²⁰ Reasons explained in response to questions 1, 14 and 18

²¹ Please see answer to question 18 for further explanation

²² <http://www.ofcom.org.uk/consult/condocs/bandmng/respnses/beirg.pdf>

Question 14. How could the database approach accommodate ENG and other similar applications?

A database can protect fixed-location incumbent services such as DVB and wireless microphones whose use is ongoing or preplanned but, as Ofcom indicate, it is not a viable solution for itinerant wireless microphone use, which includes ENG and certain outdoor sports events.

'Ring-fencing' for ENG is not a viable option because it would preclude coordinated usage in these channels and reduce available spectrum for fixed-venue applications, further limit the scale of productions that would be able to take place²³ and limit the band manager's flexibility.

Therefore, the database approach must be coupled with a requirement for sensing such that wireless microphone use (or indeed any other use) not registered in the database would, hopefully, be detected by a cognitive device and the channel avoided.

Question 15. What positional accuracy should be specified?

It appears that 3-10 metres should be practical, given current commercial technology; the specified positional accuracy should be at a comparable level.

Wireless microphones typically have a working range of 100 metres. Thus, a positional accuracy of 100 metres would make it likely that a cognitive device could interfere with a wireless microphone due to positional uncertainty alone

The exclusion zone required for PMSE will be dictated by the transmitter-power of the cognitive device. We are concerned about allowing license-exempt devices to operate at high power levels based on information from a database. It is highly unlikely that any database could have enough information about local conditions to determine remotely what the maximum allowed power should be. In addition, this would completely invalidate any possibility of securing interference protection by means of spectrum sensing. Rather, the maximum power should be capped according to the type of device, and whether it is operating on an adjacent or non-adjacent channel.

We are also concerned that geolocation does not work indoors; Ofcom must mitigate this problem by ensuring that the database approach is coupled with a requirement for sensing.

Question 16. How rapidly should the database be updated? What should its minimum availability be? What protocols should be used for database enquiries?

The database would need to be updated very rapidly because frequency requirements are often not known until the start of the production and occasionally moments before they are needed, for example:

1. Production requires 'extra' frequencies because those already secured are not sufficient to 'do the job'
2. Interference problems experienced in already licensed frequencies so ad hoc migration is required
3. The production itself is not planned

Therefore, the database would need to be updated immediately (i.e. real-time) upon provision of information from licence holders. If this proves unrealistic then the cognitive device would need to have sensing capabilities within the regulator's agreed parameters as a requirement.

The database must be available all the time. If this proves not to be possible then PMSE applications in that database would be offered no protection and therefore the cognitive device

²³Please see our response to the cleared and geographic interleaved award consultations for further information on this.

would need to have sensing capabilities within the regulator's agreed parameters as a requirement.

Ofcom have suggested 'Internet-based protocols and standard enquiry languages'²⁴. A database is not a solution for devices that lack Internet connectivity. Therefore, cognitive devices would need to have sensing capabilities within the regulator's agreed parameters as a requirement.

Question 17. Is funding likely to be needed to enable the database approach to work? If so, where should this funding come from?

Not the PMSE sector or band manager.

As the database will be 'part and parcel' of cognitive devices being brought onto the market, the funding of that database must be provided by the manufacturers who bring those devices onto the market.

Question 18. Should the capability to use the database for spectrum management purposes be retained? Under what circumstances might its use be appropriate?

Yes, absolutely. The conditions of cognitive access must be that devices use the geolocation database approach in addition to sensing. Ofcom must retain the ability to ensure that, if any cognitive devices interfere with PMSE applications, then it will not happen in the future and the sensing approach in isolation cannot ensure this. Therefore, all cognitive devices must make use of the geolocation database to determine which channels they can use at that location as a requirement.

However conservative the sensing or geolocation parameters of cognitive devices, they are only theoretical. Even if the cognitive devices meet these specifications and attain approval, Ofcom cannot ensure that they will not interfere with licensed users in practice. The capability to use the database for spectrum management purposes must therefore be used (if after the event) to address interference issues if they arise. We believe that this would align with Ofcom's duty under section 4 of the Wireless Telegraphy Act 2006 to 'provide...assistance to persons complaining of interference with wireless telegraphy' and section 8 paragraph 5 which states that the condition of licence-exempting certain applications is that their 'use... is not likely to involve undue interference with wireless telegraphy.' If a device has caused interference²⁵ to PMSE then it cannot be said that it is not likely to do so, particularly if the reason for the interference is not known. Also, the legality of use of cognitive devices must surely come into question if they interfere harmfully with licensed users.

The use of this capability would be appropriate in any circumstances where interference to licensed services had occurred and it should be used in such a way as to prevent the interference occurring again beyond all reasonable doubt.

As Ofcom say, 'all cognitive devices could be deactivated by fully populating the database with "all channels in use in this location"²⁶ or "individual channels could be "turned off" either nationally or in particular geographic areas'²⁷. If harmful interference occurs to PMSE or DTT from one or more cognitive devices then it would only be appropriate and effective to 'turn off' **individual** channels if it can be proven that the particular cognitive device(s) that caused the interference is only capable of operating in those channels. If particular cognitive devices interfere with DTT or PMSE then all interleaved channels in which those particular cognitive devices are capable of operating must be 'turned off' in order to stop more harmful interference occurring. It would also be ineffective to 'turn off' channels in particular geographic areas as opposed to

²⁴ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 6.11

²⁵ As explained in the introduction, any interference to PMSE applications is harmful, and therefore undue

²⁶ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 6.17

²⁷ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 6.17

nationally unless the cognitive device was immovable²⁸, which we do not believe is a likely scenario.

Ofcom state that ‘control could be tailored to individual devices – for example if a device were known to have a fault that was causing interference it could be turned off via the database’²⁹. We agree that, if a device that is causing interference could be definitively identified then that model should be turned off via the database. However, if the device that causes interference cannot be identified by its make and model then Ofcom should take broader measures to ensure that harmful interference does not continue.

Question 19. Should any special measures be taken to facilitate the deployment of cognitive base stations?

Base station transmissions must not cause any interference to PMSE applications or use PMSE-allocated spectrum.

Question 20. Where might the funding come from to cover the cost of provision of a beacon frequency?

Not the PMSE sector or the band manager.

If the beacon frequencies are ‘part and parcel’ of cognitive devices being brought onto the market, the funding for provision of those frequencies must be provided by the manufacturers of the devices that use the beacon frequencies.

Beacon transmissions must not be deployed on frequencies allocated for PMSE and must not interfere with PMSE applications.

Question 21. Is a reliability of 99.99% in any one location appropriate? Does reliability need to be specified in any further detail?

In absence of beacon transmissions, cognitive devices must not be permitted to transmit (i.e. no information provision from beacons must mean ‘no available frequencies’ not ‘all frequencies are available’). Ofcom indicate that this will be the case³⁰.

Question 22. Do you agree with our proposal to enable both detection and geolocation as alternative approaches to cognitive access?

No, for the reasons explained above, the detection and geolocation are both necessary requirements to protect PMSE from harmful interference. In line with this, Ofcom acknowledge that ‘both approaches could...be amalgamated’³¹.

In relation to the comparison between the three approaches of geolocation, detection and beacons, Ofcom have stated that ‘an approach based on geolocation databases appears to offer the lowest potential for harmful interference’³² and that it (geolocation) offers ‘the most efficient use of the spectrum and does not require any trade-off between harmful interference and efficiency, unlike

²⁸ Or indeed if the channel in question was only available in that geographic location. However, if this was the case then it would also be ‘turned off’ nationally.

²⁹ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 6.17

³⁰ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 7.4 states ‘The beacon network needs to have a high level of availability. If it were to fail or be taken offline, all cognitive use would cease until it became available again.’

³¹ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 8.9

³² <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 8.3

the other two approaches'³³. Despite this, Ofcom have stated that their 'inclination is to enable both³⁴ detection and geolocation databases and allow stakeholders to determine which approach they prefer'³⁵.

We believe that Ofcom's 'inclination' to allow either approach does not go far enough to ensuring that harmful interference to licensed users does not occur.

As stated in the answer to question 18 above, the geolocation approach is required in addition to sensing because this is the only way by which Ofcom can address interference caused by cognitive devices when it occurs. In addition, and as Ofcom acknowledge, 'detection might result in harmful interference due to the possibility that the cognitive device is shadowed from the signal that it is trying to detect'³⁶. Please see answer to question 7 for further views on this.

As stated in the answer to questions 14 above, the geolocation database approach is not a viable solution in isolation because

1. It cannot cater for itinerant wireless microphone use, which includes ENG
2. It is not a solution for devices that lack Internet connectivity
3. The database would need to be updated in real-time to ensure interference to PMSE is avoided. It is yet to be proven that this is possible.
4. The database would need to be available all the time to ensure interference to PMSE is avoided. It is yet to be proven that this is possible.

FCC white spaces rules have only permitted hybrid geo-location/spectrum sensing devices to be submitted for certification, thus reinforcing the conclusion that both technologies need be in place to protect incumbent operations.

Question 23. Should we restrict cognitive use of the interleaved spectrum at the edge of these bands? If so, what form should these restrictions take?

Yes. Cognitive devices should not impinge upon PMSE use of channel 38³⁷, or any other bands awarded to the band manager, in any way. Should guard bands be required, they must not reduce useable bandwidth for PMSE.

Question 24. Do you agree that there should be no limits on bandwidth?

There might be a requirement for a minimum bandwidth (e.g. 500 kHz) to ensure that cognitive devices can distinguish wireless microphones from other cognitive devices. Also, the power spectral density should be limited in order to minimize the possibility of creating additional interference due to IMD products if devices operate with reduced bandwidths.

Question 25. Do you agree that a maximum time between checks for channel availability should be 1s?

Less than 1s would be more desirable. This would help to cater for immediacy of use and reduce the likelihood of interference when, for example, users enter the auditorium already using the wireless application or other PMSE device.

Question 26. Do you agree that the out-of-band performance should be -44 dBm?

³³ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 8.5

³⁴ I.e. either

³⁵ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 8.9

³⁶ <http://www.ofcom.org.uk/consult/condocs/cognitive/cognitive.pdf> section 8.2

³⁷ If it is allocated to PMSE

This seems to be acceptable, though lower power levels would obviously be preferable and reduce the likelihood of interference occurring.

Question 27. Is a maximum transmission time of 400ms and a minimum silence time of 100ms appropriate?

The fundamental condition is that, whatever transmission and silence time parameters are decided, the devices must not interfere with PMSE applications.

Question 28. Is it appropriate to allow “slave” operation where a “master” device has used a geolocation database to verify spectrum availability?

No. As explained more fully above, **all** cognitive devices in a “network” (2 or more devices that are interconnected) should be required to (a) undertake detection/sensing as per the parameters agreed and (b) share sensing data to mitigate against hidden terminal problems. FCC accepted this and it is a condition of their rules.