30 April 2009

MSTV Response to Ofcom's cognitive device proposals

The Association for Maximum Service Television, Inc. ("MSTV") welcomes this opportunity to comment on Ofcom's consultative paper, *Digital dividend: cognitive access*, published 16 February 2009. MSTV applauds Ofcom for making its rationale and technical analyses available for public comment and response before final rules are put in place. MSTV strongly supports such an open and transparent process and believes that it will provide for better rules and regulations.

MSTV is a nonprofit trade association of local broadcast television stations committed to achieving and maintaining the highest technical quality of the local broadcast system in the United States. To inform its activities in the U.S., MSTV often looks to scientific and engineering developments in other countries, including the United Kingdom. In the same spirit of collaboration, MSTV regularly shares the benefits of its experience in spectrum management with engineers, scientists and regulators outside of the United States. The subject of Ofcom's consultation — the protection of consumers' broadcast reception amidst the introduction of new, license-exempt devices — is one in which MSTV has particularly relevant experience. During the past decade, MSTV has conducted extensive analysis of the complex technical and policy issues raised by the introduction of such devices into the broadcast spectrum.

In its responses below, MSTV does not address the issue of whether Ofcom's proposals are sufficient to develop practical or commercial cognitive devices. MSTV comments are limited to the question of whether the proposals put forth provide adequate protection of existing licensed broadcast and wireless microphone operations used by the broadcast and program production communities. In this regard, it is our technical assessment that the proposals fail to sufficiently protect these existing licensed operations.

Ofcom Report Fails to Recognize Interference Potential of Cognitive Devices or to Take into Account Variations in Signal Levels Over these Interference Distances

MSTV believes that there is a fundamental problem with the approach suggested in the Ofcom Report. The Report's premise appears to be that only a cognitive device transmitter located *near* a TV receiver can cause harmful interference.

> The language in Section 4.2., for example, states that "(i)f a cognitive devices transmits near the receiver …" and in Section 4.4 states "(a) house receives a

DTT signal using a rooftop directional aerial … . (*n)earby* is a mobile cognitive… .” (Emphasis added.)

The premise of the study is that the interference threat from a cognitive device is limited to a short distance from the victim TV receiver. This assumption is incorrect and MSTV believes is a fundamental flaw in the study.

Measurements by the FCC confirm that co-channel interference from a cognitive device operating at about 100 mW can occur over considerable distances. In the FCC measurements, the FCC separated the cognitive device and the TV receiver by distances of 270 meters or more.[1] Even in this situation with 270 meter separation, the transmitter power had to be reduced from about 100 mW by up to 27 dB before harmful interference went away. It should also be noted that the desired signal in this case was 6 to 9 dB above the Threshold of Visibility (TOV) so did not represent the “worst case” TV receive signal.

In summary, the FCC test data confirms that the potential co-channel interference distance of a cognitive device to a TV viewer using an outdoor antenna can be significantly more than 1 km. Therefore, any analysis that assumes that the concern is only a cognitive device in the immediate vicinity of a TV receiver or where the cognitive receive is nearby is incomplete and will most likely result in interference to viewers. The signal and propagation variations of DTT signals that occur over the interference radius or distance of the cognitive device need to be fully considered.

Executive summary

Question 1. The executive summary sets out our proposals for licence-exempting cognitive devices using interleaved spectrum. Do you agree with these proposals. Answer. No. MSTV believes that cognitive devices based on sensing alone will not protect licensed services, especially at the sensing levels proposed. MSTV believes that the report fails to adequately consider the potential for interference from such devices and fails to consider the lack of any remedy to correct interference should it occur from cognitive devices that rely solely on sensing. MSTV also believes that several of the technical analyses used in the Report are flawed or do not take into account a number of important factors as explained more fully below. MSTV believes that correcting these analytic errors would at a minimum lead to requirements that the power levels permitted for operation of cognitive devices be significantly lower than proposed and that the sensing levels needed for protection of DTT licensed services be reduced to a value well below the -114 dBm proposed. It is MSTV’s strong belief however that sensing alone is not sufficient to protect DTT or wireless operations and a geo-location approach has the potential to provide more reliable protection and offer more efficient secondary license-exempt use of the broadcast television spectrum.

[1] See *Evaluation of the Performance of Prototype TV-Band White Space Devices Phase II*, OET Report, FCC/OET 08-TR-1005, dated October 15, 2008 at Table 4-2 on page 32.

Detection

Question 2. Do you agree that the sensitivity level for DTT should be -72 dBm?
Answer. No. While the protection of digital terrestrial television (DTT) service is a policy decision, it is our understanding that the intent of the proposal is to protect DTT viewers within the DTT service area which in the U.K. is defined at the -70 dBm level. To the extent that the proposal extends interference protection to an area somewhat beyond the "protected DTT contour" distance by adopting a -72 dBm level, MSTV supports that intent and believes this to be an appropriate objective or goal. Unfortunately, in MSTV's experience and in practice, such an approach will not actual protect all DTT operations within the DTT service area from interference by devices using sensing technology.

DTT signals are subject to signal blockage and fading and will vary by both location and time. A DTT receiver even located well within the DTT protected service contour may be receiving a signal above -70 dBm at one time and then due to fade or other propagation conditions may be receiving a signal below -70 dBm on another occasion.[2] As long as the fade or condition does not cause the signal being received to fall below the TOV of a DTT receiver (or about -84 dBm) the DTT receiver and viewer will not experience a disruption of DTT service. Therefore, while -72 dBm or 2 dB beyond the service contour may be appropriate to define a *protected area* in a geo-location scheme, MSTV does not believe that the -72 dBm value is the appropriate value to be used for the sensitivity level or protection of DTT receivers. TOV or -84 dBm is a more appropriate value.

MSTV also takes exception with regard to Ofcom's statements in paragraphs 5.4 to 5.6 of that suggest that DTT networks in the U.K. *are planned* to provide viewers with a -70 dBm level of service and therefore "less than 0.1% of households who are considered to be in areas covered by broadcast will actually experience a level below -72 dBm." Similar planning is done for DTV in the United States. However, planning levels and actual reception levels can vary quite dramatically due to a number of factors. For example, planned signal levels assume an aerial at a certain height with a certain gain using cable with certain losses. All of these factors can and do change as consumers make individual choices on what equipment to buy and how they are installed. For example, in stronger signal situations, many consumers may rely on simple indoor antennas or outdoor antennas with less gain than assumed in modeling, thus effectively reducing the "planned" signal level to one that may be closer to TOV. In addition, signal variability, building attenuation and other propagation effects also can effect the actual signal level received. While Ofcom suggests that its assessment that 99.9% of all viewers receive a signal above -72 dBm is based on "detailed" modeling work, MSTV respectfully disagrees with the accuracy of this assessment. To suggest that the modeling done is this precise in representing actual consumer reception conditions is highly

[2] Alternatively, a DTT receiver at one house may be receiving a strong signal on a channel but a nearby neighbor may not get a useable signal on that channel.

misleading and inconsistent with the many practical factors involved in over-the-air DTT reception. To illustrate this point, MSTV notes the measurements taken by ERA Technology Ltd for Ofcom. Table 13 of the ERA Report, *Analysis of hidden node margins for cognitive radio devices potentially using DTT and PMSE spectrum,* by B.S. Randhawa, Z. Wang, and I. Parker, shows the standard deviation of average DTT signal values for six TV channels at 10 meter height taken in the Borough of Croydon varied from ± 13.1 to ±10.5 showing that actual signal variation can be quite significant even with identical receiving equipment.

MSTV, therefore, respectfully suggests that the DTT sensitivity should be based on TOV or -84 dBm. We believe that this is a much more appropriate value since it defines the point at which DTT service can no longer be achieved and therefore interference protection is no longer necessary.[3]

Question 3. Do you agree with an additional margin of 35 dB resulting in a sensitivity requirement for cognitive devices of -114 dBm?
Answer. No. While MSTV has significant disagreement with the FCC's White Space decision, the FCC did correctly describe the interference problem presented by a cognitive sensing device. This language from paragraph 80 of the FCC item is cited below:

> We generally agree that interference protection should not be afforded where service is unavailable… . However we also recognize that the signals of a low power *unlicensed device operating at a location within a TV station's noise-limited contour where the station's service is not available also could reach areas where service is in fact available and thereby cause interference*. (Emphasis added.)

The proposed 35 dB value is apparently derived from an ERA study that looked solely at the differences between received signal strength **at the same outdoor location** with antenna at 0.5 or 1.5 meters (street level) and 10 meters in height (roof top). The ERA Report, *Analysis of hidden node margins for cognitive radio devices potentially using DTT and PMSE spectrum,* by B.S. Randhawa, Z. Wang, and I. Parker, states that "(f)or data measured in the suburban and urban environments in the Borough of Croydon, the hidden node can vary between -4.1 dB … to 35.7 dB... For 99% of locations (2.576σ) a hidden node margin of 33.7dB is required.[4]" However, this is only one piece of the equation. Since the interference range of even a very low power device (100 mW) can be more than a kilometer, one needs to also take into account the variability of signal strength over these large distances, as well as the variability that can occur by having the device indoors and outdoors. In fact, the data collected in the Borough of Croydon (see

[3] Of course, the calculating the required sensing level needed for a cognitive device must also take into account, the differences in the receive systems used, the propagation variability that can occur over the interference range of the cognitive device, and other practical and actual factors that occur when these devices are used.

[4] See *ERA Report* at pages 50 and 52.

Figures 25 and 26 in ERA report) show signal level variations of as much as 45 dB from location-to-location within a three kilometer square area.

In this regard, MSTV believes that a common interference scenario that was not investigated by Ofcom is a slight modification of the scenario set forth in Figure 7 on page 20. In this new scenario, the cognitive device is also located indoors with the signal to the mobile cognitive device in back room blocked by the front of the building. However, instead of DTT reception located indoors, DTT reception is being accomplished with an outdoor antenna under weak DTT signal conditions. This simple change in the scenario in MSTV's opinion would require additional margin. For example, a cognitive device located in the first house on the first floor in a back room may see the difference of 35 dB than the rooftop antenna of the home next door as measured by ERA. However, the device may also see several dBs of *additional* attenuation from the walls of the residence. At the same time, the device would have clear "line of sight" (for example, through a rear window) to the outdoor antenna being used for DTT reception.

Ofcom also appeared to rely on statements by certain "coalition" members with regard to indoor signal variability. Ofcom's statement in paragraph 5.15, that measurements made by the "coalition" in the US suggested that the variation within a room was never measured as greater than 5 dB, is incorrect and based on misinformation.[5] While such a conclusion was made by Microsoft in a power point presentation, in fact a review of the actual data submitted with this presentation shows that this is not the case and the statement is unsubstantiated. For example, the "coalition" data at site A, "Carlsbad, Plumtree," shows measurements taken on Channel 25 in the "Family Room" varied by **more than 19 dB** from -60.5 to -79.9 dBm; and, on Channel 38 on the "Patio" by **more than 17 dB** from -82.6 to -99.9 dBm. At site B, Carlsbad Church, measurements taken on channel 30 on the "Altar" vary by **more than 18 dB** from -68.9 to -87.1 dBm. At site C, "High Rise Condo," measurements on Channel 38 in Apt 7B show differences of more than 13 dB from -101.7 to less than -115 dBm in Apt 7B and **more than 15 dB** from -99.3 to less than -115 dBm in "Parking" area. At site D, "Irvine Residence" measurements taken on channel 30 in the "Kitchen" show a difference of **more than 22 dB** from -92.4 to less than -115 dBm. Many more examples are available in the data that show variations significantly in excess of the 5 dB claimed. As to Ofcom's reliance on this "5 dB" data and its statement that "(t)herefore, we consider that the margin needed for external antennas will be more than sufficient to accommodate this case," this statement is incorrect and not based on the actual data submitted to the FCC by either Microsoft or other parties.

In fact, a close look at the data submitted by Microsoft directly addresses the question asked by Ofcom on the -114 dBm sensing level. The Microsoft data shows that a device

[5] Ofcom cites to a September 21, 2007 filing by Harris, Wiltshire and Grannis on behalf of Microsoft and Philips. As noted above, both this study and another more substantial study submitted by "White Space Coalition" member the New America Foundation show such variations can be on the order of 20 dB or more. All of this data is publicly available in the FCC docket and clearly contradicts the finding that such variation is only 5 dB.

sensing at the -114 dBm level would have failed to correctly detect the presence of a television signal in 122 trials where there was a viewable television signal (using a TV antenna) or the device was within the protected contour of a TV station. In fact, sensing at the -114 dBm level failed to provide interference protection to TV reception on one or more TV channels at 7 of the 11 sites tested by Microsoft.

The inadequacy of the -114 dBm level was also reported by the FCC. The FCC in deriving a *non-worst case* sensing level model suggested a signal sensing level "as low as -124 dBm or less" was needed. The -114 dBm was a value that the FCC stated "appears to be technically feasible at this time" with the main protection for licensed services being derived through a geo-location approach. (See paragraphs 79 and 75 respectively of November 2008 FCC R&O.)

Finally, even if the 35 dB margin is deemed sufficient and used it should be applied to TOV value of a DTT receiver for the reasons explained above and not -72 dBm level. This alone would require amending the Ofcom requirement for the cognitive device to sense to -126 dBm rather than -114 dBm value proposed.

Question 4. Do you agree with a maximum transmit power level of 13 dBm EIRP on adjacent channels and 20 dBm on non-adjacent channels?
Answer. No. MSTV believes that the adjacent channel power of 13 dBm is too high and that there is an inconsistency in the calculations deriving this number. First, in paragraph 5.24, there is an assumption that the free space loss for 10 meters is approximately 50 dB. This value is incorrect. As noted in paragraph 5.43, the free space path loss at 10 meters is around 46 dB. A difference of 4 dB. Accordingly, the adjacent channel power allowed should be reduced by at least 4 dB or less than 10 dBm from this factor alone.

We also note that for many available consumer DTT antennas there is not a 4 dB difference in antenna gain at an angle of 45 degrees and distance of 10 meters. For example, the Philips Manta is a small popular amplified UHF antenna that we believe would not have such discrimination. In addition, a cognitive device located in a second or third story window next to a similar building with a rooftop DTT antenna would not be at an angle of 45 degrees. In this case, the cognitive device would be in the main beam of the DTT antenna and there would be no difference in gain between DTT signals and interfering signals from a cognitive device. Nor would there be an increase in distance from the slant angle.

The Ofcom calculations are also based on a received signal level of -72 dBm. As described above we believe that this value should be -84 dBm or -81 dBm (3 dB above TOV) if some additional margin is deemed appropriate to ensure DTT reception is reliable and since adjacent channel interference will be restricted to a more limited area. Using these values in the Ofcom analysis yields the following values: 1) a free space loss for 10 meter distance of approximately 46 dB; 2) 0 dBi total gain; 3) 5 dB cable loss; and, 4) a -30 dB adjacent channel C/I.

Using these values in the Ofcom's analysis contained in paragraphs 5.24 and 5.25, leads to a total path loss of 51 dB rather than the 55 dB assumed.

The level that the adjacent channel signal should not exceed based on a signal level of either -84 or -81 dBm rather than -72 dBm is -84 or -81 +30 = -54 or -51 dBm. Hence, the maximum transmitted power signal level would be around 0 dBm or 1 mW based on a 10 meter separation and realistic protection of DTT signals closer to TOV.

Question 5. Would it be appropriate to expect DTT equipment manufacturers to improve their receiver specifications over time? If so, what is the best mechanism to influence this?

Answer. MSTV believes such improvements would only come about if cognitive devices proliferate rapidly and cause interference to DTT customers such that this performance improvement becomes a feature desired and easily recognized by the consumer. The more likely occurrence however is that both cognitive device proliferation and interference to DTT would occur over time. In this situation, it is unclear what will happen when there are sufficient cognitive devices to cause large numbers of DTT viewers to be disenfranchised and therefore encourage DTT equipment manufacturers to improve receiver performance. One possible outcome would be for consumers to simply abandon local over-the-air capability for satellite or cable services rather than purchase new receivers that may still be at risk of interference from cognitive devices. MSTV believes strongly in the continuation and importance of over-the-air DTT services including local news, information and emergency information. MSTV also believes that the significant public investments made to purchase new wide screen DTV receivers should be protected. Therefore, if improved DTT receiver performance is desired, MSTV believes that early government intervention and regulation is necessary to drive that improvement.

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

See Response to Question 8 below.

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

See Response to Question 8 below.

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

Answer. Yes. While we have not confirmed the values in questions 6 and 7, MSTV believes that the -126 dB sensitivity requirement appears appropriate and consistent with our experience in this area. However, based on testing in the United States, MSTV also believes that the conditions under which this value is specified and measured should also be well defined. For example, MSTV notes that the performance of sensing was severely impacted in the presence of strong adjacent channel television signals or when actual DTV captures were used rather than unimpaired test signals. To fully protect licensed

wireless microphone operations, such a sensitivity requirement must be met under all these real world conditions.

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?
Answer. No. As indicated above, MSTV believes that the maximum transmit power levels for cognitive devices to protect DTT should be reduced significantly from 13 dBm to the 0 to 5 dBm range. We also believe that minimum bandwidth of at least 4.5 MHz should be specified to ensure that multiple transmissions are not permitted within the same channel and that the power is measured across the entire DTT channel. We believe that at this reduced power levels, the transmit powers needed to protect wireless microphone operation and DTT reception are generally in-line and front-end receiver overload is a manageable problem.

Question 10. Do you agree that the sensitivity level for mobile television receivers should be -86.5 dBm?
Answer. For the U.S. ATSC mobile system, the planning sensitivity level for mobile receivers is somewhat lower at -94 dBm.

Question 11. Do you agree with an additional margin of 20 dB for mobile television?
Answer. MSTV agrees that some additional margin should be taken into account based on the fact that the separation between the cognitive device and a mobile television receiver can be quite small and on the range of one to two meters. Given the small form factors and the potential use patterns, it is highly likely that cognitive devices and mobile television receivers can be used at the same locations; certainly, there will be less than 10 meters separation between mobile and cognitive devices. In this regard, note that the standard for GSM handsets specifies a distance of 1 meter between handsets for instance.

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?
Answer. In the US, mobile television operations will occur on the same channels used for traditional in-home television reception by using advance coding and other techniques on a portion of the data being transmitted by the television station.

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?
Answer. MSTV does not believe that there is sufficient "real world" data at this time to take into account cooperative sensing or to develop specifications (for example number of sensing locations, separation distances, etc.) for such a requirement.

Geolocation databases

Question 14. How could the database approach accommodate ENG and other similar applications?
No comment.

Question 15. What positional accuracy should be specified?
Answer. MSTV believes that a positional accuracy of 50 meters or less would be sufficient.

Question 16. How rapidly should the database be updated? What should its minimum availability be? What protocols should be used for database enquires?
Answer. How often the database is updated depends largely on how often the database must be accessed by the device to get channel information. The most important aspect for communications are to ensure that the device can only talk to an "authorized database" and that communications between the database and the device are fully protected and secure.

Question 17. Is funding likely to be needed to enable the database approach to work? If so, where should this funding come from?
No comment.

Question 18. Should the capability to use the database for spectrum management purposes be retained? Under what circumstances might its use be appropriate?
No comment.

Question 19. Should any special measures be taken to facilitate the deployment of cognitive base stations?
No comment.

Beacon reception

Question 20. Where might the funding come from to cover the cost of provision of a beacon frequency?
Answer. MSTV believes that since the benefit of operation accrues to the cognitive device operator and manufacturer, they should be responsible for all funding and costs. Licensees should not have to pay for the operation and deployment of new equipment that is used solely to allow others to operate without causing interference to existing users.

Question 21. Is a reliability of 99.99% in any one location appropriate? Does reliability need to be specified in any further detail?
No comment.

Comparing the different approaches

Question 22. Do you agree with our proposal to enable both detection and geolocation as alternative approaches to cognitive access?
Answer. As indicated above, MSTV does not believe that detection alone is sufficient to protect incumbent operations.

Other important parameters

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?
No comment.

Question 24. Do you agree that there should be no limits on bandwidth?
Answer. No. MSTV believes that a minimum bandwidth of 4.5 MHz is needed to avoid multiple emissions within any one 8 MHz television channel. The C/I ratio of 30 dB being used is based on a single interfering signal to the DTT receiver and takes into account the total power across the entire 8 MHz channel. For example, 4 two megahertz devices each operating with an EIRP of 200 mW and transmitting at the same time would present significantly more power and therefore more interference potential to the DTT receiver than a single wideband emission of 200 mW. Alternatively, one could define a maximum power level and spectrum density limit to achieve a similar result.

Question 25. Do you agree that a maximum time between checks for channel availability should be 1s?
Answer. Yes. The maximum time between checks should be sufficiently brief to prevent interference to roving wireless microphone operation such as those used in electronic newsgathering.

Question 26. Do you agree that the out-of-band performance should be -44 dBm?
Answer. No. MSTV believes that more stringent out-of-band performance is required and that the assumptions at the origin of this out-of-band performance requirement may need to be re-visited. For example, the IEEE 802.22 established, with the wireless microphone manufacturers, that the minimum signal level to be protected is –95 dBm and that the protection ratio is 20 dB. This results in a value of –115 dBm as the maximum out-of-band signal level in 200 kHz to avoid interference. This corresponds to –115 + 10*log(8000/200) = -99 dBm in 8 MHz bandwidth at the wireless microphone receiver. With an assumed path loss of 32 dB, this corresponds to –67 dBm out-of-band signal level in 8 MHz at the license-exempt device. For a 20 dBm transmit power, this corresponds to 87 dB rejection. Trying to avoid interference from out-of-band emission from license-exempt devices at 1-2 m from the wireless microphone receivers will be very difficult.

If the separation distance is increased to 10 m, then the out-of-band emission level raises to a more reasonable level around –49 dBm corresponding to an out-of-band rejection of 79 dB for a 20 dBm transmit power. This is 5 dB tighter than what is being proposed by Ofcom. In addition, in its white space analysis to protect DTT operations, the FCC in its decision required a more stringent out-of-band rejection of about 55 dB in the first adjacent channels.

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

Defining a minimum sensing time is a prerequisite for all sensing schemes. To ensure that devices can actually detect or "hear" licensed operations, it may be desirable to synchronize the sensing time of all cognitive devices.

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

No comment.