



OSA's response to the public consultation on the Radio Spectrum Policy Group's draft report on "Cognitive Technologies"

Submitted by the Open Spectrum Alliance (OSA)

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This document presents OSA's views on the draft report by RSPG on "Cognitive Technologies". It also addresses some basic issues related to license exempt spectrum use by cognitive radios, including coexistence with digital terrestrial television (DTT) and Programme Making and Special Events (PMSE) systems in the UHF band. At the end we suggest some changes to and offer comments on the draft report, including some notions that may be controversial.

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I. Introduction

RSPG is to be commended for initiating this forward-looking consultation to gather contributions for a report that provides a useful overview and good guidance for CEPT, BEREC (the new European body of electronic communication regulators), the European Parliament and Commission, EU member states, the general public and interested parties around the world.

Spectrum policy has traditionally been viewed through a lens of "spectrum scarcity" – a perspective which declares that frequency bands must be rationed to a limited number of selected users in order to avoid overcrowding and harmful interference. The rigidity of this approach is now understood to increase spectrum scarcity. Although license auctions and trading have introduced some flexibility into this "command-and-control" model, the high cost of participation in these processes (as well as other factors) severely limit the licensee applicant pool.

Fortunately, RSPG was quick to recognise the benefits of the "collective use of spectrum" model, and the European Commission recognised even earlier that restrictions on market entry, innovation, flexibility, efficiency and competition resulted from requiring radio licenses when less burdensome procedures are sufficient to achieve quality-of-service and policy goals.

Although Europe-wide measurements of occupancy are not currently available, an extensive monitoring campaign by Germany's Bundesnetzagentur in 2006 found a vast amount of underused spectrum between 9 kHz and 275 GHz.¹ A 2007 study of spectrum occupancy in Dublin, Ireland, likewise found a large amount of underused channels in all the frequency bands measured during a two-day period (see Figure 1, next page).² These remarkably low utilisation levels show there is great potential for extracting more benefit from the radio spectrum through improved band- and device- management and without immediate risk of overcrowding.

Cognitive radios are able to share bands with existing users on an opportunistic basis while avoiding interference to licensed incumbents or other primary spectrum occupants. As the RSPG's draft report notes, they "have the potential to play an important role, not only in increasing the efficiency of spectrum usage by offering new sharing opportunities, but also in providing more versatility and flexibility to applications as a result of their ability to adapt their operations..."

II. Potential Benefits of Widespread CR Use

Today we are at a critical juncture. The huge impact of broadband services on economic growth and productivity, the availability of cognitive radio technologies (CRT) and the transition to Digital Terrestrial Television (DTT) have come together to create an unparalleled opportunity to improve the lives of all Europeans. *EU policymakers can release large swaths*

¹ *Frequenznutzungsplan gemäß TKG über die Aufteilung des Frequenzbereichs von 9 kHz bis 275 GHz auf die Frequenznutzungen sowie über die Festlegungen für diese Frequenznutzungen*, Bundesnetzagentur (May 2006), available at <http://www.bundesnetzagentur.de/media/archive/1820.pdf>

² Tugba Erpek, Karl Steadman, David Jones, "Spectrum Occupancy Measurements: Dublin, Ireland, Collected on April 16-18, 2007," Shared Spectrum Company, 2007, available at http://www.sharespectrum.com/measurements/download/Ireland_Spectrum_Occupancy_Measurements_v2.pdf.

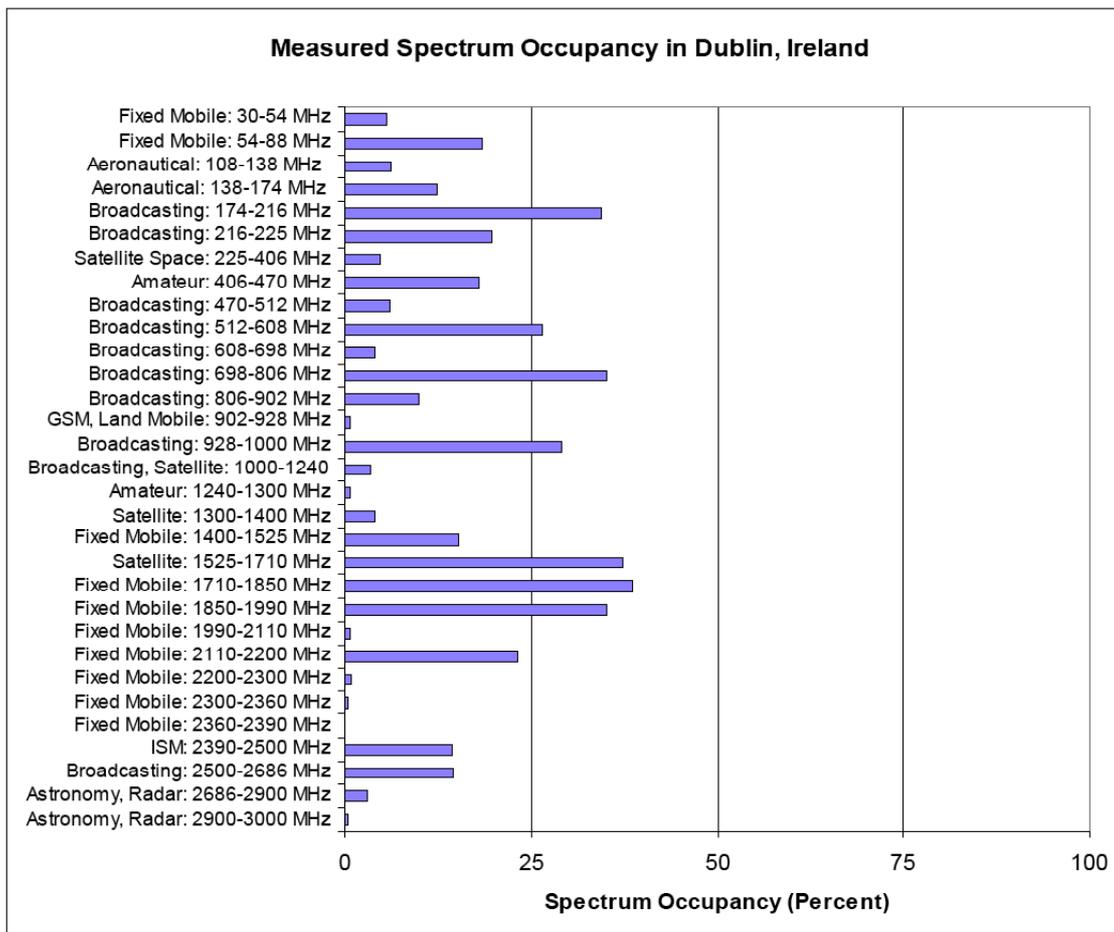


Figure 1. Spectrum Occupancy in Dublin, Ireland, on 16-18 April 2007.
Source: Shared Spectrum Company

of spectrum for more inclusive, empowering and non-hierarchical services, address digital divide issues, and remove crippling barriers to innovation for future growth.

The European Union has set a goal of providing broadband Internet access for all citizens of the member states by 2010.³ Yet studies still show wide differences in broadband penetration rates between urban centers and sparsely populated regions,⁴ as well as between Eastern and Western Europe.⁵

The operation of wireless networks using CR in the UHF band could deliver broadband to currently underserved and unserved areas at less cost per user than any other method.⁶ *The*

³ "EU Call for Universal Broadband", BBC News, 26 September 2008, available at <http://news.bbc.co.uk/2/hi/7637215.stm>.

⁴ Eurostat, "Use of the Internet Among Individuals and Enterprises," March 2006, p. 3, available at http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NP-06-012/EN/KS-NP-06-012-EN.pdf.

⁵ Eurostat, "Internet Usage in 2009 – Households and Individuals," December 2009, p. 2, available at http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-09-046/EN/KS-QA-09-046-EN.pdf.

⁶ "Not-spots" – areas without broadband Internet – are mainly found in sparsely populated rural regions. Analyses in the US and UK have shown that most white space spectrum is also found in such regions. So there is likely to be a strong rural bias in the emergence of broadband networks based on WSDs in CEPT member states – a bias that may mitigate the "digital divide".

Lisbon goals would thus be well-served by opening the Digital Dividend to low-cost CR services which expand broadband access.

Spectrum Engineering Working Group 43 (SE43) of the European Conference of Postal and Telecommunications Administrations (CEPT) has begun defining the technical conditions for CR use of TV "white spaces" in the UHF band. OSA supports the use of UHF in the initial deployment stages of CR, but our concern is growing that SE43 may make such use impractical (see below).

II.A. Connectivity for CRs

To encourage the development of broadband services at UHF, the technical conditions adopted for CR use of TV "white spaces" should encourage white space devices (WSDs) to function as Wireless Access Systems (WAS) including Radio Local Area Networks (RLAN) and Internet services.

If WSDs function as Internet access points, there are several important consequences. First, one can safely assume that *every WSD will be connected to the Internet.*

Second, if geo-location databases of the RF systems entitled to protection from WSD interference are put online to help CRs identify locally available frequencies, then every WSD should be able to access this data. *That means no WSD will be solely dependent on spectrum monitoring to find safe-to-use frequencies.*

Third, *network connectivity means CRs at different points in a single service area can monitor the RF environment cooperatively.* Dispersed devices are far less likely to be correlated in the detection of weak signals, thereby mitigating the "hidden node" problem. That means *the protection margin for weak signals shadowed by environmental obstacles does not have to be nearly so large for cooperating CRs as is necessary for reliable detections by non-cooperating devices* (see Figure 2).

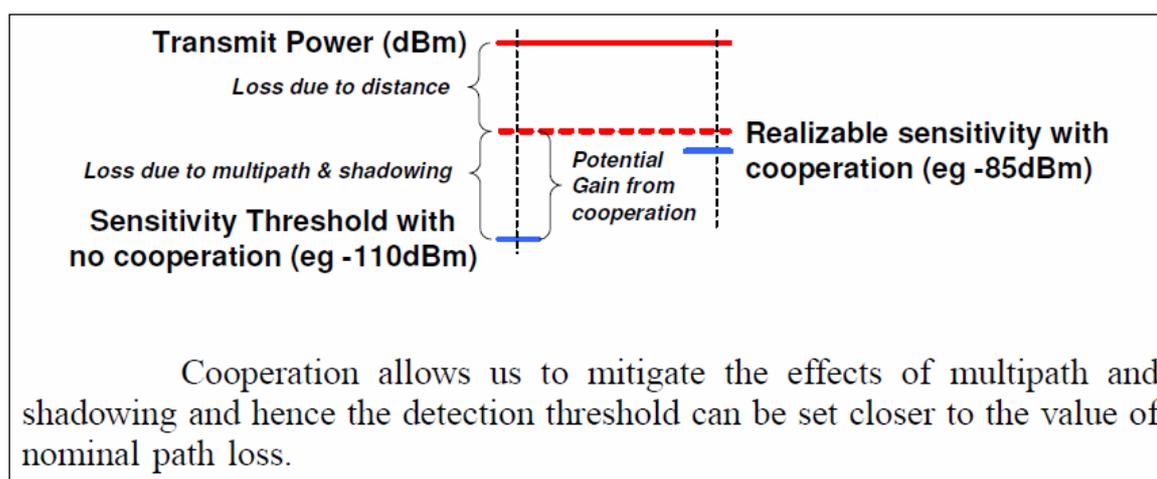


Figure 2. Source: study by S. M. Mishra, A. Sahai and R. W. Brodersen.⁷

⁷ S. M. Mishra, A. Sahai and R. W. Brodersen, "Cooperative Sensing among Cognitive Radios", presented at the IEEE International Conference on Communications, 11-15 June 2006 (Istanbul, Turkey), available at http://bwrc.eecs.berkeley.edu/php/pubs/pubs.php/156/ICC06_paper.pdf.

So if CRs are connected to the Internet and have on-demand access to geo-location databases, and if they engage in cooperative sensing of local spectrum occupancy with other similar CR devices nearby, the elements are in place for exemption from licensing with very limited risk of harmful interference even without an overly large fading margin added to the detection threshold.⁸ In fact, a study by the New America Foundation of CR devices operating in the UHF band determined that "the probability of harmful interference can be made so small that electric power outages would be a more likely cause of interruption to broadcast TV service than unlicensed TV band devices".⁹

II.B. Detection Thresholds

Tests conducted in 2007 by the US Federal Communications Commission (FCC) demonstrated that the detection of DTT transmissions by prototype WSDs is feasible even below the noise floor. Field studies completed by prototype manufacturer Philips indicate that *most hidden node situations* – in which a node of an incumbent occupant is hidden from CR line of sight by any topographical obstacle – *were reliably addressed by detection thresholds of -109 dBm to -114dBm*. However, the lower the detection threshold is, the more white space use is compromised (see below for more on this point).

The American and European standards for digital television transmissions are not the same, as the RSPG's draft report points out. That does not mean the results of the FCC's detection tests are irrelevant for Europe. *It means Europe should conduct its own tests of WSD prototypes to determine adequate levels of effectiveness in DTT detection.*

Research in the US also demonstrates that the required detection sensitivity and rules for WSD use of channels adjacent to those occupied by DTT transmissions have major impacts on the amount of available white space. According to Mishra and Sahai, the average number of white space channels in the lower part of the UHF band across the US is about 15. However, "this number drops significantly (to ~5) when adjacent channels also have to be protected... Fixed threshold rules (for example the -114dBm rule proposed by the FCC for ATSC signals) are very conservative and result in almost no channels per person (especially when adjacent channels are considered)".¹⁰

The sensitivity requirement imposed by the FCC did not take into account detection gains possible with cooperative sensing by networks of CR devices. However, growing scientific evidence and the FCC field tests themselves suggest that focusing on worst case scenarios and total reliance on any one cognitive technique leads to significant limitations on white space operations and, by extension, on the development of broadband in interleaved UHF spectrum. OSA therefore urges the RSPG to balance the protection of incumbent services with the

⁸ CRs lacking some basic cognitive abilities – or which fail to fulfill the requirements for license exemption – could also be authorised but under tighter control: *e.g.*, as light-licensed or registered equipment. This recognises that cognitive capabilities can to some extent replace regulatory interventions. At the same time, exemption from licensing can provide an incentive to the development of equipment which is effectively self-regulating.

⁹ Mark A. Sturza and Farzad Ghazvinian, "Can Cognitive Radio Technology Operating in the TV White Spaces Completely Protect Licensed TV Broadcasting?" New America Foundation (January 2007), available at http://wirelessfuture.newamerica.net/publications/policy/can_cognitive_radio_operating_in_the_tv_white_spaces_completely_protect_licensed_tv_broadcasting.

¹⁰ M. Mishra and A. Sahai, "How much white space is there?", Berkeley Wireless Center, University of California at Berkeley, Technical Report number UCB/EECS-2009-3, available at <http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-3.html>.

benefits that would flow from more intensive and efficient use of that part of the radio spectrum.

II.C. PMSE Systems and Wireless Microphones

PMSE systems – particularly wireless microphones, whose location and duty cycle are highly variable – pose a much greater challenge for CR systems than DTT. *CEPT Report 24* (2008) proposed to test whether WSDs “can reliably detect the presence of a [Professional Wireless Microphone System] emission at a level of -116 dBm.” However, if professional users of wireless microphones were obliged to register their frequencies, locations and activity times in the databases checked by WSDs, then uncertainty in the sensing of such weak signals could be reduced with information from human sources and interference into nearby systems would be more readily avoided. Since license exempt radio systems normally enjoy no interference protection rights (even when they are “incumbents”!) and wireless microphones are unlicensed in several CEPT countries, regulators could use registration in the geo-location database used by CRs as a requirement for the granting of protection rights to license exempt PMSE services.

An alternative solution (proposed by the US-based White Spaces Coalition) is to require all CRs to recognise and react to a simple authentication code transmitted by a “wireless microphone protection beacon” transmitting at a power level of +16 dBm in the center of a TV channel indicating that that channel should be avoided because wireless microphones near the beacon are using the adjacent frequencies.

“...the beacon detection threshold for the [WSD should be set] relative to the device’s transmitting power. For example, the rules should establish a 1 dB for 1 dB correlation between the beacon detection level and the device’s transmit power, which would require a device proposing to transmit at 36 dBm to detect the same beacon at a level 26 dB lower than a device proposing to transmit at 10 dBm... [A] stand alone beacon for an existing user looking to add a second layer of protection for an entire 6 MHz channel will be only \$40 to \$50 and, in large quantities, could be in the range of \$10 – a tiny fraction of the total system cost of the wireless microphone...”¹¹

III. International Telecommunication Union (ITU) Activities

The RSPG draft report suggests that a change to the International Radio Regulations may be needed to support spectrum allocations for CR services on a service-by-service basis. OSA’s current position is that specific allocation decisions for CR operation should not be made at the ITU level. To facilitate the greatest flexibility and potential for innovation in cognitive radio, and to provide for the most widespread expansion of broadband services for public access and other uses, the ITU should let its members authorise CR operations on any and all unoccupied frequencies. For the same reasons, definitions of Software Defined Radio and Cognitive Radio Systems should not be incorporated in the Radio Regulations, as ITU-R Study Group 1 aptly stated in its preliminary conclusion. This position is now also echoed by the United States draft proposal for Agenda Item 1.19 and by the draft proposals of an increasing number of other nations as those proposals become available.

¹¹ Edmond J. Thomas, “Unlicensed Operation in the TV Broadcast Bands”, *ex parte* filing, ET Docket No. 04-186 (17 June 2008) - <http://www.wirelessinnovationalliance.org/files/Beacon%20ex%20parte%20FINAL.pdf>. Note that the White Spaces Coalition explicitly rejects IEEE 802.22.1’s beacon proposal as too costly and technically overspecified.

IV. POLICY RECOMMENDATIONS

This section summarises the policy recommendations in the above discussion.

IV.A. Conduct Transparent Analyses of Spectrum Usage

A Europe-wide survey of radio band occupancy would enable regional spectrum management entities to identify new candidate bands for the introduction of cognitive sharing. Such a survey should be repeated regularly with the results made public.

IV.B. Promote License Exempt, Opportunistic Use of Spectrum

The RTT&E and Authorisation Directives put Europe at the forefront of spectrum policy reform globally. Together they established the principle of minimising burdens and restrictions on market entry in the wireless realm. Allowing CR devices access to underused channels now will keep Europe at the forefront, while creating new opportunities for economic growth and social cohesion by expanding broadband services into regions that are poorly served or unserved.

IV.C. Assume that the First CRs will be Internet Access Points

In developing its policies for CR, RSPG should ensure that public access to Internet services is at the top of the agenda, along with the goal of delivering broadband access to all Europeans by 2010.

IV.D. Include Cooperative Sensing in Scenarios for the Development of Technical and Operational Requirements for CR Services

Cooperative sensing is the next stage of CR development although it is already practical today. It reduces the need for ultra-low detection thresholds and thus increases the amount of white space which is practically available.

IV.E. Don't sacrifice innovation & efficiency to preserve a medium in decline (over-the-air TV broadcasting)

Despite the claims of broadcasters, reasonable signal detection thresholds can protect DTT from WSD interference. Worst case scenarios are not the norm. RSPG should weigh the relative importance of increasing public access to wireless broadband against a few rare cases of DTT interference.

IV.F. Promote more robust receiver standards to minimise interference and facilitate bandsharing

Requiring DTT and other receiver types to be more robust against interference would enable more intensive band sharing, dispelling the impression that "we are running out of spectrum."

V. DETAILED NOTES ON THE DRAFT REPORT

As we generally agree with the structure and content of RSPG's draft report, this section focuses on specific editorial suggestions for the report's text. The numbering below corresponds to the section numbering in the draft report.

4.1 Features of cognitive radio technologies

In the second bulleted list (currently found on page 9), add the phrase "and probability" to the second item, as shown here:

- Transmit Power Control: software protocols which, once the device has established its transmission, reduce the power to the minimum necessary, thereby reducing the level and probability of interference to other devices...

That will eliminate the implication that devices with TPC always produce *some* level of interference.

4.2.1 Sensing

The "hidden node" problem is discussed in the third paragraph of this section. We suggest adding a paragraph (after the picture on page 10) describing a few ways to mitigate this problem. The draft report already refers to such measures near the top of page 11, but without linking them to hidden nodes. It is important to emphasize that the "hidden node" problem need not be fatal:

There are at least two ways for networked cognitive radios to mitigate the "hidden node" problem: one way is through "collaborative" sensing – sharing information gathered by monitoring the local radio spectrum from different locations. Environmental obstacles cannot cast radio "shadows" in every direction simultaneously so one or more CRs is likely to be in a position to detect a primary user even when others in the network are not. An appropriate "polling" protocol then lets the network advise its nodes that the channel is occupied. A second option is to add receivers to the network in locations with superior reception, e.g. above nearby buildings or in line-of-sight to a known primary transmitter. In such cases the protection margin for shadowed weak signals does not have to be nearly so large as for non-collaborative detection, nor does the full detection capability have to be present in each CR device.

The paragraph after the picture on page 10 states:

Another problem facing pure spectrum sensing and monitoring methods is that it is also not possible to detect receive-only users such as passive radio astronomy services and other scientific users.

This point is reiterated in the fifth bullet-point of section 9:

Purely passive usage is impossible to detect...

Is it only a myth, then, that monitoring vans can detect TV sets being used in homes which have not paid their license fees to receive public service broadcasts?

We draw your attention to a paper by Ben Wild and Kannan Ramchandran presented at DYSpan-05 (the IEEE Symposium on New Frontiers in Dynamic Spectrum Access Networks, November 2005) entitled "Detecting primary receivers for cognitive radio applications," (available online at http://bwrc.eecs.berkeley.edu/Research/Cognitive/ben_wild_dyspan_final.pdf). Here is part of the abstract:

"it has been assumed that many devices in primary networks such as televisions and cellular phones are passive, *i.e.* the cognitive radio cannot find their locations. In this paper we show how we can take advantage of the Local Oscillator (LO) leakage power that all RF receivers emit to allow cognitive radios to locate these receivers. We show that our detection approach can detect the LO leakage with very high probability and takes on the order of milliseconds to make a decision. We then propose a new architecture consisting of sensor node detector devices that detect the LO leakage and communicate the channel usage to the cognitive radios..."

There may be receivers that the Wild/Ramchandran approach cannot detect. But given the extreme sensitivities likely to be built into CRs (as the RSPG's draft report observes on page 11), at least some receiver sensing may be possible. Therefore, if the RSPG wishes to mention the issue anyway, but without getting too technical, the report should use more cautious language, *e.g.* use the phrase "it may be difficult" rather than "it is also not possible" as shown here:

Another problem facing pure spectrum sensing and monitoring methods is that it may be difficult to detect receive-only users such as passive radio astronomy services and other scientific users.

A similar adjustment should be made to the fifth bullet-point in section 9.

Our final suggestion for section 4.2.1 involves the third paragraph from the end:

...the receiver parameters of the existing users should be known too. This issue needs to be addressed in any future spectrum management decision.

Unfortunately, it may not be enough to *know* the receiver parameters. Mandating improvements in the interference resistance and selectivity of a primary service's receivers would reduce the risk of sharing a band with cognitive devices and the added costs could be much less than the added social benefits. (A cost-benefit analysis could be performed as part of the normal regulatory impact assessment process.) The EC's consultation document "Transforming the digital dividend opportunity into social benefits and economic growth in Europe" (10 July 2009) suggested higher receiver standards in section 4.1.b ("Setting standards for the ability of digital TV receivers to resist interference"). In addition, *CEPT*

Report 127 (October 2008), "The impact of receiver standards on spectrum management", also recognised the growing importance of this approach in improving the efficiency of spectrum use. Instead of putting the cost and performance burdens of interference protection entirely on cognitive devices, RSPG's report could encourage CENELEC to develop technical standards to make certain receiver types less vulnerable to interference, as was suggested earlier this year by the Information Society and Media Directorate-General.

4.3 Pre-cognitive radio systems

The bulleted list in this section describes how regulatory institutions at the European level are to develop the technical conditions for spectrum access by cognitive radio devices. Rather than passively describing the process, RSPG's report could be used to fine-tune it.

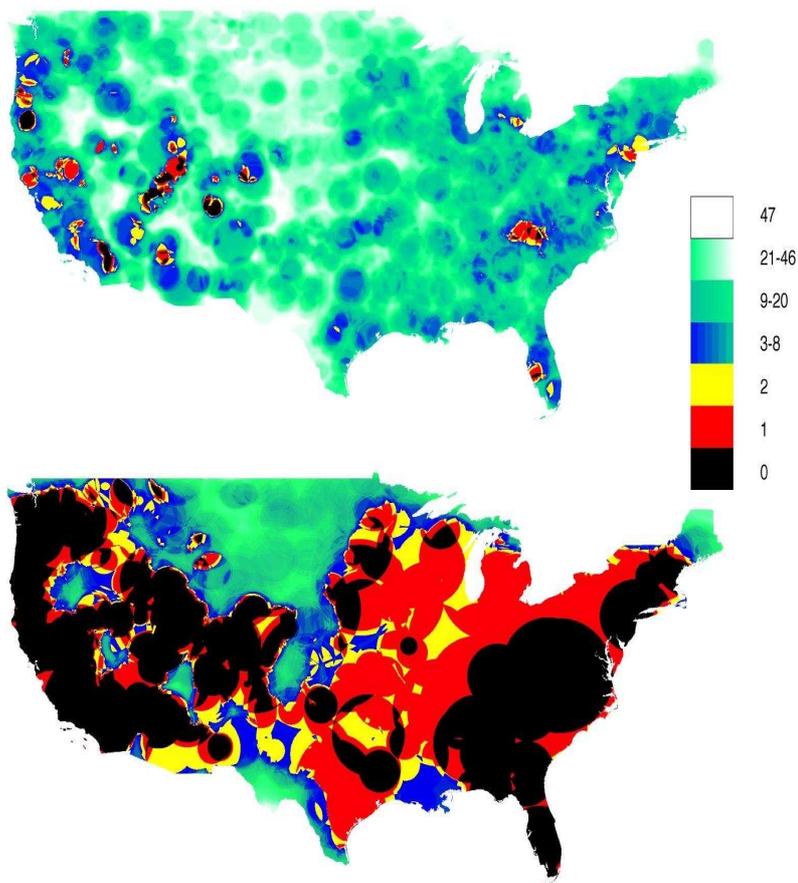
For example, in the current draft, "appropriate test methods" are only mentioned in the third bullet point of section 4.3, in the context of ETSI ensuring "compliance with the technical conditions" derived from CEPT's compatibility studies.

CEPT's compatibility studies for WSDs have so far included *no testing of prototype devices* – in contrast to the US Federal Communication Commission, which conducted both laboratory and field tests under a variety of real-world and controlled conditions. CEPT has not even proposed "appropriate test methods" that national regulatory authorities could use on their own initiative for WSDs.

CEPT seems instead to be relying on theoretical abstractions, mathematical models and arguments based on the worst case scenarios conjured up by the incumbent services. (As the first bullet-point in this section of the draft report indicates, protecting incumbents is virtually the only aim of the SE43 task group.) As a result, the technical conditions set for WSDs by CEPT are likely to be so conservative that a high rate of "false detections" is inevitable, rendering most of Europe's white spaces unusable. That is not a problem for DTT or PMSE systems; they would rather have no WSDs in the UHF band at all. So what if WSDs are required to be so sensitive that they mistake a small change in the background noise level for a distant DTT or PMSE signal that isn't really there? DTT and PMSE remain protected, even when overprotected.

The effect of such overprotection on the geographic availability of white space was made visible recently by a researcher at the Berkeley Wireless Research Center in California. Mubaraq Mishra used the FCC's published rules for cognitive access to TV white spaces to generate maps of the US (minus Alaska and Hawaii).¹² See next page. The upper map shows the number of channels available for WSD use at each location according to the geo-location database, which is designed to protect DTT stations within their licensed service area. The lower map shows the number of channels available based on spectrum monitoring, with the FCC's incumbent signal detection requirement of -114 dBm. Black indicates the areas where there is no usable white space; red indicates the areas where there is only one 6 MHz channel available. Even though these maps show the FCC's sensitivity requirements greatly exceed what the database says is sufficient – in effect putting the risk of WSD interference to DTT far below zero – CEPT's current discussion of signal thresholds for Europe suggests that they will put the detection threshold even lower, the protections for DTT and PMSE even

¹² The methods used to calculate white space availability are described in M. Mishra and A. Sahai, "How much white space is there?", Berkeley Wireless Center, University of California at Berkeley, Technical Report number UCB/EECS-2009-3, available online at <http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-3.html>



The upper map shows the availability of UHF channels for use in the continental US by license-exempt "white space devices" if one follows the FCC's rules for geo-location database lookup. The lower map shows the availability of UHF channels if one follows the FCC's rules for sensing the primary users' transmissions with a -114dBm detection threshold. Both maps produced in 2009 by Mubaraq Mishra <smmm@eecs.berkeley.edu> at the Berkeley Wireless Research Center, California.

higher. That is why we indicated earlier that we are concerned that SE43 will make technical requirements for the authorisation of WSDs practically unattainable.

Therefore, we encourage the RSPG to insert a sentence or two after the bulleted list in section 4.3 of the draft report, reminding CEPT that

European spectrum policy in the 470-790 MHz band not only aims to protect the current incumbent services, it aims to promote the efficient and flexible use of spectrum and maximise the benefits of digital switchover for all Europeans. Unnecessarily restrictive conditions for cognitive access to DTT white spaces defeats those aims. Testing prototype WSDs in the field and in the laboratory – using methods and scenarios not devised exclusively by incumbents – may be essential to the discovery of the technical conditions necessary to protect existing primary services.

Concluding our suggestions for section 4.3, the third paragraph from the end also needs modification. It currently says:

The recent introduction of pre-cognitive devices has raised the issue of putting constraints on the future development of other uses of a frequency band especially when these devices are under a license-exempt approach. This is because the technical conditions can only be defined based on known protection requirements of the incumbent users. Hence, CRT devices will need to be able to adapt to new sharing conditions in line with the evolution of other radio systems.

A similar misperception is found in the final paragraph of section 5.3:

It is to be expected that with a growing use of CR, refarming will become more complex where there is a large number of invisible CT devices active in spectrum bands.

In fact, input from frequency use rule and geo-location databases is likely to be a prominent feature of CRT devices for a long time to come. The creation of such databases for cognitive radios to check while operating (as discussed in sections 4.2.3 and 5.4.1 of the draft report) gives regulators a powerful new tool for controlling and changing equipment behaviours after deployment. License-exempt cognitive radios actually pose less problem to the future refarming of bands than non-cognitive radios whose operating parameters are fixed. All that is required for the implementation of change in CR is enough flexibility in the design of the database for the variables and rules to be modified as needed later. The database could even tell devices to shut down permanently. Putting active CR databases and highly sensitive end-user owned spectrum monitoring equipment "in the field" is likely to revolutionise the regulator's role in frequency management. So the above-quoted paragraph might be replaced with this:

Unlike pre-cognitive devices, CRT does not assume or require that spectrum management policies will remain static. The ability to adapt which characterises CRT increases the probability that any future change in band use, primary user characteristics or sharing practices can be accommodated.

With the FCC raising the spectre of UHF channels now used for DTT being reallocated to broadband, it is possible that the geo-location database created in the US for WSDs might actually outlive over-the-air television. The database servers could easily be supplied with new data to protect licensed broadband from – for example – short-range multimedia devices. RSPG might likewise note in its report that CEPT should recognise the need for the geo-location databases it creates for WSDs to support the evolution of cognitive radio technology beyond the needs of today's incumbents. Many people believe that the future of radio is cognitive. We agree.

VI. About OSA

Founded in Vienna last May, the Open Spectrum Alliance (<http://openspectrum.eu>) is a coalition of companies, organisations, and individuals working to unlock the potential of bandwidth for all. We are united by the goal of expanding the social and economic benefits of the radio spectrum through the adoption of innovative public policies. The members of OSA are Aaron Kaplan, Alexander List, Armin Medosch, Christoph Schindler, Georg Erber, Joseph Bonicioli, Juergen Neumann, Kamilla Kovacs, Malcolm Matson, Michael Haberler, Ramon Roca, Robert Horvitz, Rupert Nagler, Sascha Meinrath, Tano Bojankin, Vic Hayes

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OSA's partners and supporters include the Athens Wireless Metropolitan Network, Freifunk.net, Funkfeuer.at, Guifi.net, Open Society Institute, Open Spectrum Foundation, Open Technology Initiative, Shared Spectrum Company, and Skype.

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