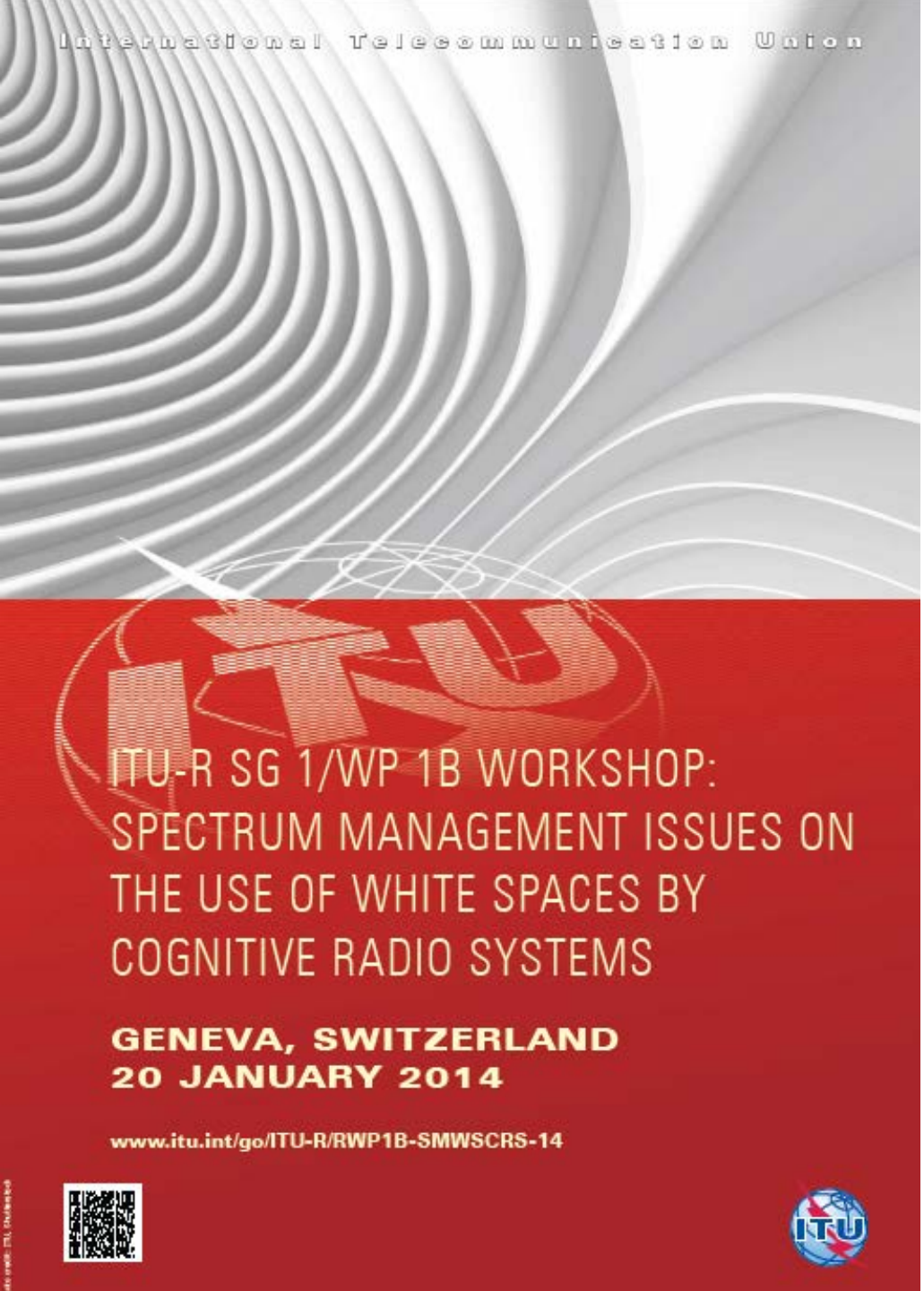


ITU-R SG 1/WP 1B WORKSHOP: SPECTRUM MANAGEMENT ISSUES ON THE USE OF WHITE SPACES BY COGNITIVE RADIO SYSTEMS (Geneva, 20 January 2014)

Opportunistic use of Spectrum – Horn of Plenty or Pandora's Box

John Shaw

Horn of Plenty or Pandora's Box?

Horn of Plenty (from Latin *cornu copiae*):

A symbol of abundance, nourishment or wealth in some form

Pandora's Box: A beautiful box, or large jar (Greek *pithos*), is given to Pandora, 1st woman on Earth, by Zeus with the instruction not to open it. Of course it is opened and instead of a great treasure it turns out to contain all the evils of the world. Now meaning a seemingly small or innocent action that turns out to have severe and far-reaching consequences.

Expectations from White Space

- Commissioner Michael Copps of the FCC is reported as saying: *"One of the lessons of history I have learned since coming to the commission is the power of technology to turn scarcity into abundance.*
- Many administrations share these expectations and see the possibilities of generating large revenues.

What could be go wrong?

- Many warnings from history about over-complexity and over-optimism.
- Complex systems can fail in completely unexpected ways.
- A wise rule: *“if something appears to be too good to be true, then it probably is”.*
- Another wise rule: *“always understand what you dealing with”*.

What is White Space?

- Many voices in Study Group 6 were critical of the term “white space”, and even more so of the term “TV White Space”. These concerns were sent to the CCV for their further consideration.
- The CCV has considered the question of terminology following representations from WP1B and WP6A on the definition of the term “white space” and related terms (such as “TV white space”, “ad hoc radio systems”

What we know

- The CCV agreed with the findings of WP6A that the following terms have a clear definition in the ITU terminology database:
  - cognitive radio system (ref. Report ITU-R SM.2152);
  - software-defined radio (ref. Report ITU-R SM.2152);
  - adaptive system (ref. RR No. 1.109A).

What we don’t know

- The following terms are not included in the ITU terminology database:
  - opportunistic radio systems
  - ad hoc radio systems
  - white space (spectrum)
  - TV white space

Further work on terminology

- The CCV now requests the further views of the concerned ITU-R Working Parties in order to continue studying and discussing the issue
- The CCV has also requested that ITU-R Working Parties share information on the different uses and possible variations in the definition of these terms

Questions to resolve

The uncertainty surrounding white space devices and systems leads to many questions, most importantly:

- How many different types of equipment need to be considered when assessing compatibility with the broadcasting service and related ancillary services?
- What is their regulatory status in the RRs?
- What other national regulatory measures may be applied?

Allocation status of white space devices (WSDs)

- There are primary and secondary allocations to the mobile service in the UHF broadcasting bands around the world which could cover some of the types of use that have been described as white space.
- There is also increasing interest in harmonising allocations so that mobile use is co-primary with the broadcasting service around the world.
- Some types of WSDs may not be covered by a corresponding allocation in the RRs

More questions

- There seems to be no international agreement on:
  - Whether the use of white space applications should only be allowed under a licence or some other form of national authorisation or regulation?
  - Whether unlicensed or unregulated white space applications could also be permitted to operate and, if so, what the relative rights of licensed and unlicensed devices should be?

Access to markets

- Normally, policy on national licensing and regulation is not a factor that is considered at international level.
- However, if devices intended for a market where no technical or administrative means of control are required are taken to countries where stricter forms of national regulation are applied then it may be expected that both the broadcasting service and regulated white space applications in those countries will be exposed to interference and degradation.

Implications of differing national regulations

- The uncertainty surrounding the design and use of white space devices has led some industry leaders to question the utility of white space devices, especially for critical applications
- The incoming chief executive of Neul, Stan Borland, was recently reported in *Policy Tracker* to be reviewing Neul's previous strategy so as to put the company's focus firmly back on the Internet of Things (IOT) and, in the process, withdrawing from its sideline in rural broadband equipment for TV white space

Problems with critical applications

- Neul's , Vice-president for Marketing, Ben Peters, was reported in *Policy Tracker* as explaining the strategy changes thus:

"While licence-exempt use has its benefits, it's quite difficult to think of health monitors or critical alarms on a wide area network depending on spectrum that is contended". TV white space is therefore *"not a 100 per cent fit"* for the IOT".

Ubiquitous unregulated use?

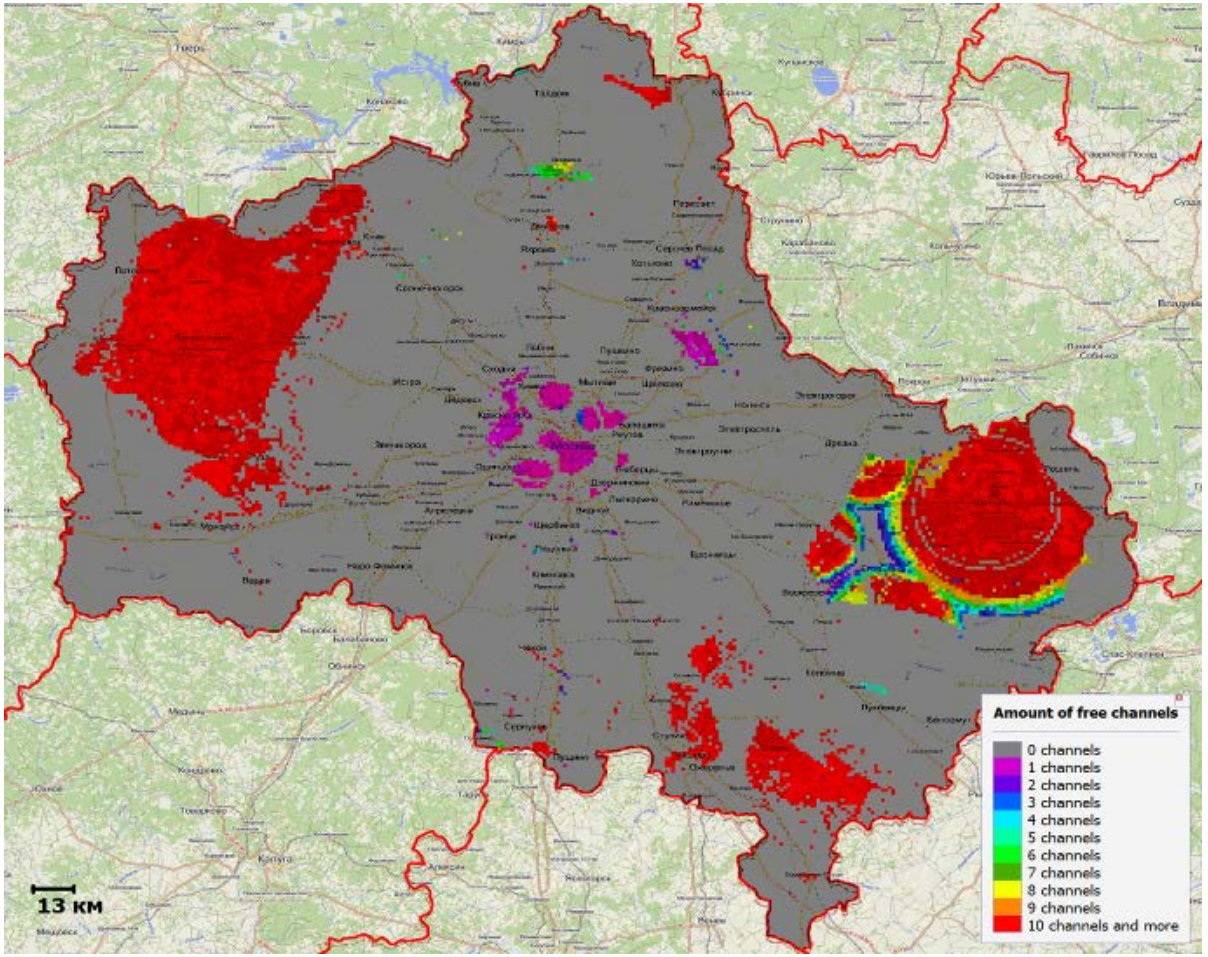
- Neul's explanation continued with the view that being successful in the IOT will require super-cheap device modules costing less than $5, coverage that is ubiquitous, and plug-and-play solutions that are very simple to use. *"These requirements made us review the spectrum we might be using"*
- Neul has therefore concluded that TVWS is not a perfect fit - one factor being that the way TVWS is currently being regulated makes it very difficult to produce "low-cost end-points".

Availability constraints

- Another drawback Neul sees is that TVWS is not available in some of the places where it's most needed. *"IOT applications tend to be positively correlated with where people are,"* whereas TVWS is typically less plentiful in cities. *"In some downtown areas in the United States, there's no TVWS at all."*
- That view was from industry, but it would seem obvious that the demand for broadcasting services and various ad-hoc or opportunistic applications will be concentrated where people live, thus creating conflict on spectrum availability

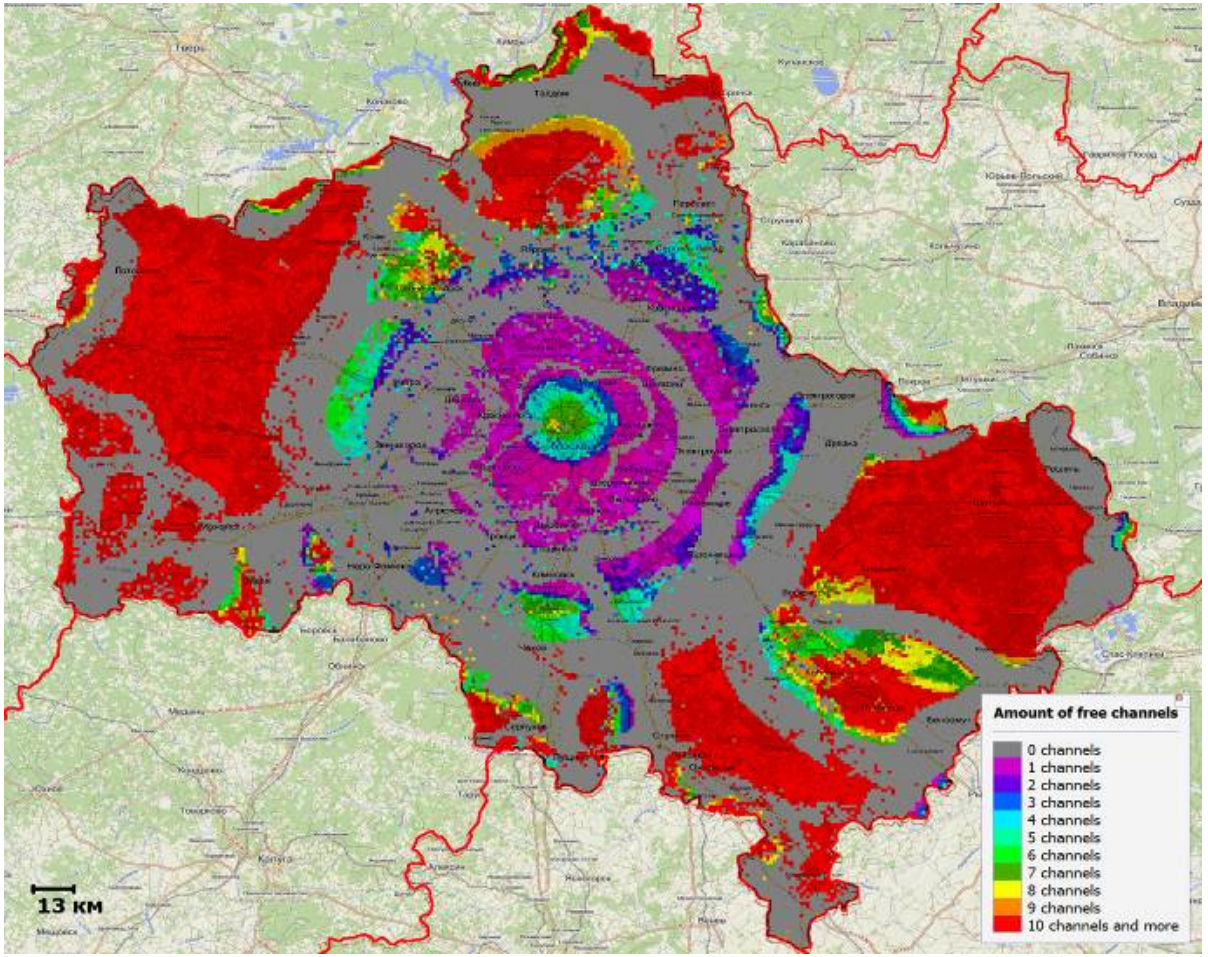
50m distance to TV receiver

(Figure A3 from Annex 9 to Document 6A/264)



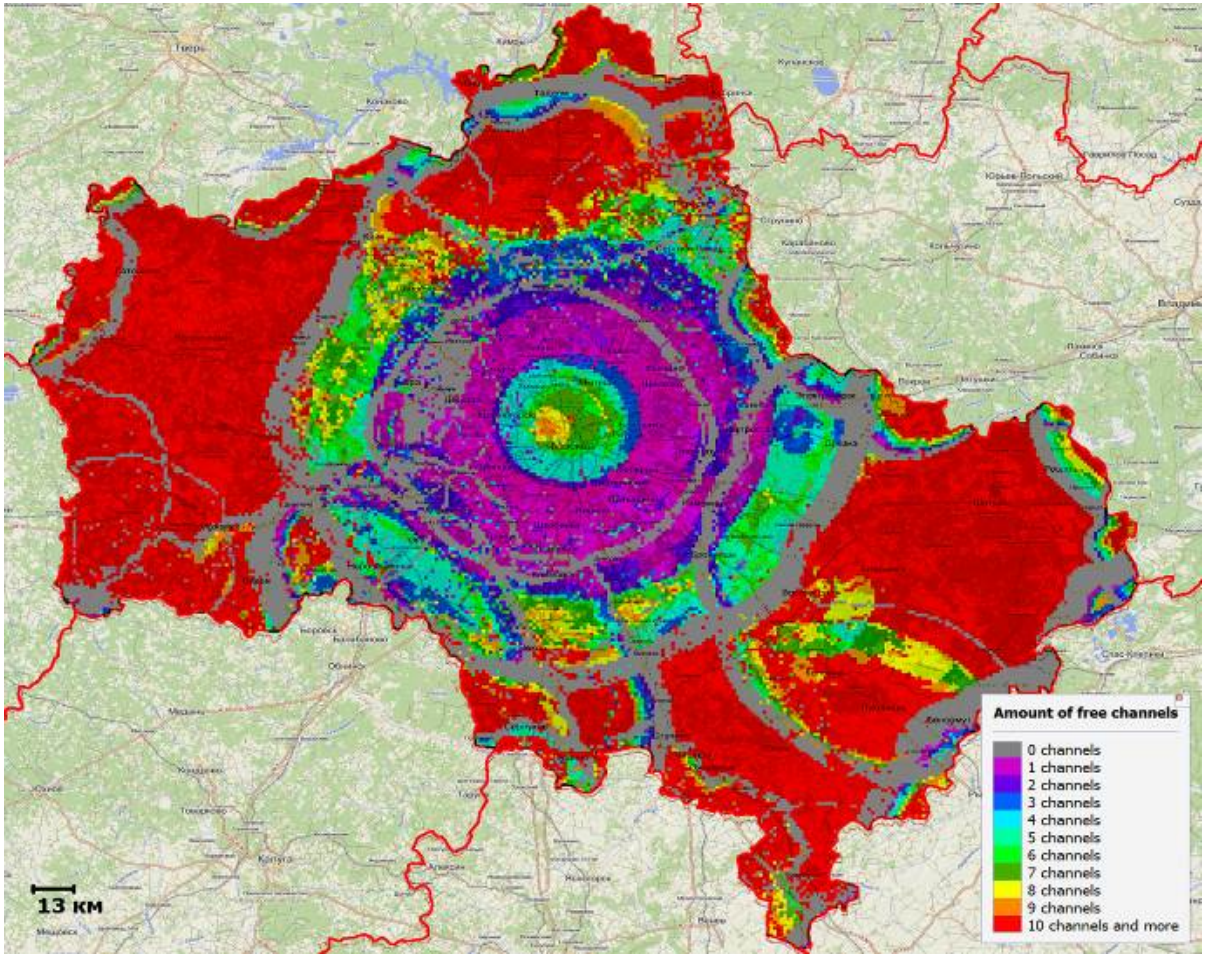
250m distance to TV receiver

(Figure A3 from Annex 9 to Document 6A/264)



500m distance to TV receiver

(Figure A3 from Annex 9 to Document 6A/264)



Need for clean spectrum for broadcasting

- Much of the work in Study Group 6 in recent years has been taken up with new threats of interference to the reception of broadcasting.
- It is of the utmost importance to the broadcasting service to have a clean radio frequency environment wherever people live so that high quality reception is always available.
- However, many devices using radio frequencies are coming to market that operate within or close to buildings and homes.

Noise considerations

- Rather than expectations of large amounts of *white space* the reality is better described as a sort of *grey mush* of noise from distant broadcasting sources and other sources of radio frequency emissions nearby.
- The addition of other sources of radio frequency emissions, whatever their name and purpose, will have one indisputable effect, which is to raise background noise levels. This will reduce the margin of safety for the reliable reception of broadcasting across service areas.

Broadcast Planning Imperatives

- Broadcast services are planned so as to achieve a certain level of field strength sufficient to overcome local background noise from man-made and natural sources and the cumulative noise from other broadcasting stations at a distance using the same or adjacent frequencies.
- Because of the need to provide the widest range of programme content, and the increasing demand for new services, the broadcasting bands are operated up to maximum capacity. New entries in major broadcasting Plans in densely populated areas (e.g., GE75, GE84 & GE06) are interference limited.

Broadcasting already makes use of coverage gaps

- It has never been the case that those parts of the broadcasting bands where there was not a usable broadcasting transmission were wasted.
- The broadcasting and audio-visual arts sector has long made use of available broadcasting spectrum for programme making and various forms of live events and entertainment.
- This is actually a form of white space use, which is likely to be compromised by diverting any available spectrum to other and higher revenue producing applications.

Applications ancillary to broadcasting

- The widespread support for accommodating applications ancillary to broadcasting within the UHF broadcasting spectrum is evidenced by RR No. 5.296

5.296 Additional allocation: in Albania, Germany, Saudi Arabia, Austria, Bahrain, Belgium, Benin, Bosnia and Herzegovina, Burkina Faso, Cameroon, Congo (Rep. of the), Côte d'Ivoire, Croatia, Denmark, Djibouti, Egypt, United Arab Emirates, Spain, Estonia, Finland, France, Gabon, Ghana, Iraq, Ireland, Iceland, Israel, Italy, Jordan, Kuwait, Latvia, The Former Yugoslav Republic of Macedonia, Libya, Liechtenstein, Lithuania, Luxembourg, Mali, Malta, Morocco, Moldova, Monaco, Niger, Norway, Oman, the Netherlands, Poland, Portugal, Qatar, the Syrian Arab Republic, Slovakia, the Czech Republic, the United Kingdom, Sudan, Sweden, Switzerland, Swaziland, Chad, Togo, Tunisia and Turkey, the band 470-790 MHz, and in Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Nigeria, South Africa, Tanzania, Zambia and Zimbabwe, the band 470-698 MHz are also allocated on a secondary basis to the land mobile service, intended for applications ancillary to broadcasting. Stations of the land mobile service in the countries listed in this footnote shall not cause harmful interference to existing or planned stations operating in accordance with the Table in countries other than those listed in this footnote. (WRC-12)

Ancillary services operating in the broadcasting bands

- Services Ancillary to Broadcasting (SAB) support the activities of broadcast service companies carried out in the production of their programme material.
- Services Ancillary to Programme making (SAP) support the activities carried out in the making of 'programmes', such as film making, advertisements, corporate videos, concerts, theatre and similar activities not initially meant for broadcasting to general public.
- The term PMSE (Programme Making and Special Events) is also used to describe these activities.

Compression of spectrum available for broadcasting

- Expectations about the existence of large amounts of freely available spectrum probably originated from the days of analogue transmission when re-use distances for co-channel and adjacent channel broadcasting stations were much larger than with digital modulation.
- The transition to digital television transmission and the subsequent pressure to remove spectrum from the broadcasting service under WRC-12 agenda item 1.17 and WRC-15 agenda item 1.2 would see the spectrum available to broadcasting in the GE06 Planning Area fall by 43% from 392 MHz to 224 MHz, as more spectrum is devoted to LTE/IMT systems.

Interference mechanisms

- Three interference mechanisms involving WSDs are of concern to the broadcasting sector :
  - Direct interference to the off-air reception of broadcasting services
  - Interference to SAB/SAP/PMSE operations
  - Interference to other ways of distributing TV services - Cable Access TV and Master Antenna

Interference to off-air reception

- The expectation is that the sensing and geo-location methods proposed for Cognitive Radio Systems operating the TV bands will be able to identify those areas where some alternative uses of spectrum are possible.
- However this is questionable - the prediction of areas of interference is not a matter of a straightforward link to planned service areas. The resolution of the geo-location database must be fine enough to handle many factors.

Interference to SAB/SAP/PMSE use

- This aspect of WSD deployment is of major concern to the broadcasting sector.
- With increasing amounts of broadcasting spectrum being re-allocated for LTE/IMT use, the spectrum available for use by SAB/SAP/PMSE operations is also very much less than before – that is before broadcasting operations were compressed into a much smaller amount of spectrum.

Concerns on SAB/SAP/PMSE operations

- The demand for SAB/SAP/PMSE is not predictable and will vary widely from day to day and from place to place.
- This will put a considerable burden on keeping geo-location databases up to date.
- The equipment used for radio cameras, radio microphones, talkback circuits etc., typically operates with low power and operation may be intermittent.
- SAB/SAP/PMSE transmissions will therefore be difficult for CRS sensing technology to detect.

Pressure on SAB/SAP/PMSE use

- Today, the operation of SAB/SAP/PMSE units is subject to detailed planning in order to avoid interference to TV reception and self-interference between units. This involves consideration of intermodulation products as well as the actual operating frequencies.
- Now, it is becoming increasingly difficult to satisfy the growing demand for SAB/SAP/PMSE use from within the remaining amount of broadcasting spectrum.
- The demand for SAB/SAP/PMSE use will be in direct conflict with demand from the high revenue white space CRS based systems in whatever pieces of broadcasting spectrum are remain available in future.

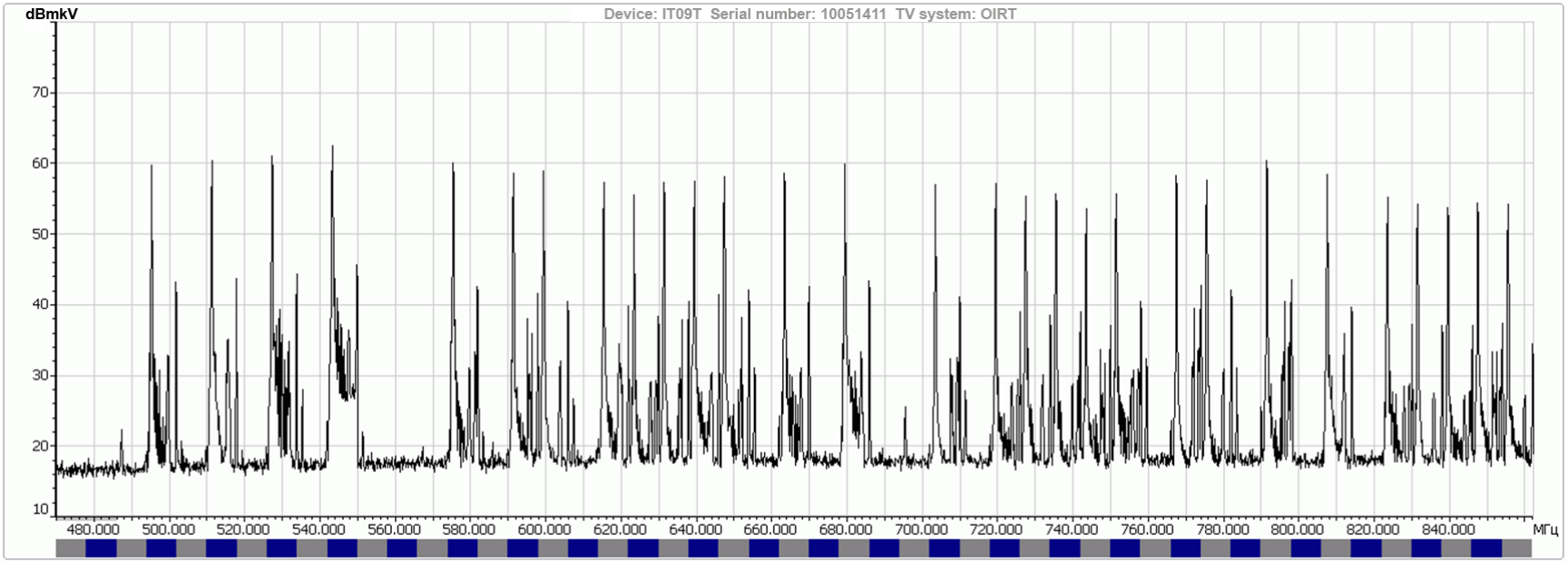
Studies on SAB/SAP/PMSE use

- Several reports are available evidencing the vulnerability of SAB/SAP/PMSE systems to interference:
  - ECC Report 185: Complementary Report to ECC Report 159 - Further definition of technical and operational requirements for the operation of white space devices in the band 470-790 MHz
  - ECC Report 186: Technical and operational requirements for the operation of white space devices under geo-location approach
  - Cambridge TV White Spaces Trial – PMSE Trials Report

Interference to CATV systems

- Even if white space CRS equipment designed for use near or within homes is able to sense off-air transmissions or have accurate geo-location information available, cable access TV systems also use the broadcasting bands I, III, IV/V, as well as spectrum in between.
- CATV systems are therefore likely to have fewer unused TV channels (if any) available.
- The main constraint on CATV operation at present is that operators tend to avoid local off-air TV channels.

Example of CATV frequency use
(Figure 4.1 from Annex 9 to Document 6A/264)



Geo-location concerns

- Will the resolution of geo-location databases be fine enough to capture all the factors and variations that define the availability of spectrum?
- Will the associated prediction tools, observations and data inputs be precise enough for populating databases with data sufficiently accurate and reliable to maintain continuing protection of TV reception?
- Will additional real-time data be captured sufficient to protect SAB/SAP/PMSE operations?
- Will it be possible to add data to protect CATV and MATV systems if administrations so wish?

Dynamic sensing concerns

- Will WSDs incorporate a toolkit so that national administrations can set thresholds according to their national policies on broadcast coverage and their objectives on frequency planning and management?
- Will WSDs be able to distinguish between received signals and apply the appropriate thresholds for protecting off-air TV reception ,SAB/SAP/PMSE operations, CATV use, or other WSDs with priority?
- Will market surveillance be effective in ensuring that the sense and avoid features of WSDs cannot be disabled and that the sensing thresholds are appropriate for use in the country concerned?

Effective market surveillance is essential

- Reliable dynamic sensing in WSDs depends on having proper equipment standards in place.
- Different broadcast planning objectives between countries will be reflected in what equipment is authorised for use in each country.
- If Country A plans for ground level portable TV reception and Country B plans only for fixed rooftop TV reception, then a device capable of sensing the higher broadcasting field strengths present in Country A may not be able to detect the lower field strength transmissions in Country B.

Can we trust market surveillance?

- How will administrations ensure that only equipment conforming with its own regulations and broadcasting planning objectives is used within its jurisdiction?
- The experience with other types of devices that depend on the use of radio frequencies has not been encouraging.

PLT/PLC example

- A huge amount of effort has been expended in WP1A and WP6A on interference problems with PLT/PLC devices.
- The maximum PSD output of a PLT modem should not exceed -55 dBm/Hz below 30 MHz
- Investigations in ITU-T SG15 on PLT//PLC interference into VDSL systems (25 kHz – 30 MHz) show many modems units giving -50 dBm/Hz – a level that can also cause severe interference to radiocommunication services.

5 GHz Wireless LAN example

- Another example of non-compliance is reported in the 5th R&TTE Market Surveillance Campaign by the EU supported ADCO group.
- This revealed a high degree of non-compliance regarding 5 GHz dynamic frequency selective Wireless LANs, which are supposed to sense and avoid aviation radars.
- The overall compliance with assessed requirements was only 28%. A major failing found was the ability of users to disable the sense and avoid features in many of the units tested.

Conclusions

- The expectations for finding and exploiting white spaces in the UHF TV broadcasting band appear to be over optimistic, especially in well-populated areas.
- Further consideration is needed on ensuring that regulation through geo-location and sensing can take account of all the factors involved in receiving off-air and cabled TV services and protecting the spectrum used for programme making and outside broadcasts

Further conclusions

- The loss of UHF broadcasting spectrum for both transmission and programme making means that opportunities for WSDs within the remaining spectrum are correspondingly reduced.
- Attention should therefore be given to finding space for WSDs elsewhere. It may be the case that there are greater prospects for finding white space from within the UHF bands newly available for LTE/IMT use.

The search for White Space

It may also be that the search for ever increasing amounts of white space will find… just that…
a blank!