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Conference Paper

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27th European Regional Conference of the International Telecommunications Society (ITS): "The Evolution of the North-South Telecommunications Divide: The Role for Europe", Cambridge, United Kingdom, 7th-9th September, 2016

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: El-Moghazi, Mohamed; Whalley, Jason; Irvine, James (2016) : International Radio Spectrum Management Regime: Restricting or Enabling Opportunistic Access in the TVWS?, 27th European Regional Conference of the International Telecommunications Society (ITS): "The Evolution of the North-South Telecommunications Divide: The Role for Europe", Cambridge, United Kingdom, 7th-9th September, 2016, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/148666>

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International Radio Spectrum Management Regime: Restricting or Enabling Opportunistic Access in the TVWS?*

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Abstract

The practice of TV white spaces (TVWS), one application of the easement approach to spectrum management, has varied around the world with limited commercial deployments and only a few trials due mainly to the delay in digital switchover and the resistance of broadcasters.

Internationally the ITU-R has discussed, at the World Radiocommunication Conference of 2012 (WRC-12), the regulatory measures that can enable deployment of cognitive radio systems (CRS). Following WRC-12, the ITU-R has started to discuss TVWS among other dynamic spectrum access (DSA) techniques.

The examination of the influence of the international spectrum regime on national spectrum policy reform, from command and control towards spectrum easements approach is based on data collected from 84 interviews and shows that the international regime does not prevent adopting opportunistic access in the TVWS. However, there are different elements of flexibility (support) and restriction (opposition) that have an influence on a regulator's decision regarding the deployment of such a concept. These elements are dependent on a country's relationship with its neighbours, the perception of the TVWS concept and the interpretation of the ITU-R Radio Regulations (RR).

There are four different perceptions on the TVWS radiocommunication service status: secondary, non-interference basis, primary, and different status according to the perceived operation of TVWS. There are contrasting perceptions on the influence of WRC-12 decision on CRS regarding TVWS adoption. There are two distinct views on the need for particular measures similar to those adopted for WLAN in the 5 GHz for TVWS such as dynamic frequency selection (DFS). This is based on the perception of TVWS service status, deficiencies of TVWS, deficiencies of DFS, difference between operation of WLAN and TVWS and positive influence of such measures on the TVWS adoption.

Finally, it is argued that the TVWS proponents were quite unlucky in terms of the timing of its deployment due to the consecutive mobile allocations in the 800 MHz, 700 MHz, 470-694 MHz spectrum bands by the WRC-07, WRC-12, and WRC-15 respectively. These have significantly reduced TVWS chances in the whole UHF band.

Paper presented at 27th European regional conference of the International Telecommunications Society,
7-9 September, Cambridge, UK

1. Introduction

“The technology is there, the only thing that stops us is policy and regulation”

H. Sama Nwana, chief executive of the Dynamic Spectrum Alliance,
addressing TVWS at ITU Telecom World 2014

The rapid growth in wireless services and the increasing demand for mobile broadband have called for re-examining how radio spectrum, a critical component in the delivery of wireless services, is managed. This has inspired several scholars to review the traditional approach to national spectrum management, ‘command and control’, where the regulator manages spectrum by designating appropriate uses, technologies and users (OECD, 2006). In particular, the command and control approach has been criticised for creating artificial scarcity that is due to inefficient utilisation rather than spectrum shortage (Wellenius and Neto, 2005).

One suggested alternative to the command and control approach is spectrum easements, which is based on allowing other users rather than the spectrum owner to use the owner’s spectrum as a non-interference easement (Faulhaber and Farber, 2003). One particular application of the spectrum easement approach is the TV white space (TVWS) concept. However, the practice of such concept has been limited without significant success or wide adoption. While this may be related to the lack of commercial devices or reluctance of broadcasters to accommodate TVWS in their spectrum, one potential factor that is largely overlooked in the debate is the influence of the international spectrum management regime on the adoption of TVWS concept. More specifically, the literature does not address the influence on national spectrum policy reform from command and control towards spectrum easements approach.

Having said that, this paper’s main question is formulated to be ‘How does the international radio spectrum management regime influence the adoption of opportunistic access in the TVWS?’. The rest of the paper is organised as follows. Section 2 examines spectrum management at the national level with a focus on TVWS while Section 3 explores the international spectrum management regime. Section 4 states the research methodology adopted for this paper. Section 5 examines the interaction between the international regime and national policies with respect to introducing TVWS in general. Section 6 examines the different views on the TVWS radiocommunication service status and then Section 7 highlights the different potential influences of the WRC-12 decision on the agenda item 1.19. Section 8 conducts a comparison between the regulatory measures adopted for the Wireless LAN (WLAN) in the 5 GHz and those needed for TVWS, while Section 9 concludes.

2. National Radio Spectrum Management Policy

One of the main suggested alternatives to the traditional spectrum management approach, ‘command and control’, is spectrum easements. Table 1 compares between the command and control and spectrum easements approaches in terms of four main dimensions: service allocation, technology selection, usage rights and assignment mode (Chaduc and Pogorel, 2008).

As shown below, the main difference between command and control and spectrum easements is with regard to the usage rights dimension. Meanwhile, property rights with easements are not necessarily associated with specific elements of the other three dimensions of spectrum management approaches.

	Command and Control	Spectrum Easements
Service Allocation	Harmonisation	Harmonisation/Flexibility
Technology Selection	Standardisation	Standardisation/Neutrality
Usage Rights	Exclusive	Property rights with easements
Assignment Mode	Administrative	Administrative/Market

Table 1: Comparison between Command and Control and Spectrum Easements Approaches

In general, easement is a certain right to use the real property of another without possessing it. Easements in spectrum were mainly proposed by Faulhaber and Farber (2003) who suggested allowing other users rather than the spectrum owner to use the owner spectrum as a non-interference easement. This is in contrast to exclusive spectrum property right, which is the basis of the spectrum markets approach, and to collective usage right, which is accommodated within the spectrum commons approach (Chaduc and Pogorel, 2008).

There are two main types of access within spectrum easements: overlay (opportunistic) and underlay access. Overlay devices access the spectrum at the geographical, time, or frequency gaps of the licensed users’ transmission as long as not causing harmful interference. Underlay access implies that a secondary user will transmit at low power levels, within the noise floor of licensed spectrum (Cave and Webb, 2012). Underlay access entails easements in power (Cave and Webb, 2003). For instance, equipment such as ultra wide band (UWB) can transmit over a broad bandwidth with very low power levels.

Overlay or opportunistic access is mainly promoted by technologies, such as cognitive radio system (CRS), which are capable of measuring the radio environment and learning from experience in order to transmit dynamically in the temporal unused frequencies without the need of exclusive allocation (Mitola, 2000). The main candidate spectrum bands for CRS

operations are the TVWS, which refer to the geographical interleaved vacant frequencies in the broadcasting spectrum. Those frequencies were allocated for the broadcasting service but were not used in a particular area or frequency because of the need of spectrum guard band and geographical separation between TV channels to avoid interference (Freyens and Loney, 2011).

The practice of TVWS has varied around the world with limited commercial deployments and trials. In the US, the FCC allowed fixed unlicensed devices to operate in the TVWS (FCC, 2006), and in 2008, fixed and portable devices were allowed to operate on the condition that they deploy geo-location capabilities and access a database (FCC, 2008). Another update was in 2012 when the FCC decided to slightly increase the maximum permissible power spectral density (PSD) for each category of TV bands device (Yang, 2014).

In India, eight experimental licences were issued for TVWS in the frequency band 470-582 MHz in 2016 (Times of India, 2016). Ofcom in the UK has enabled license-exempt operation of TVWS in the UHF band in 2015 (Ofcom, 2016). In Europe, the Radio Spectrum Policy Group (RSPG) within the European Commission (EC) recommended that introducing the CRS could be considered on the national level taking into account border coordination issues (RSPG, 2011b). The Asian Pacific countries established a task group on CRS and SDR in April 2009 to facilitate the study on these systems in their countries (APT/AWG Task Group on SDR & CRS, 2014). Moreover, several TVWS have been established especially in Africa (e.g. Kenya) (Haji, 2014) while the ATU has established a group in 2014 to study the management of TVWS technologies (ATU, 2014).

On the other hand, some countries expressed their reservation about the TVWS concept. For instance, TRA of UAE announced that there is a difficulty of deploying TVWS devices because spectrum available for TVWS is getting smaller (Almarzooqi, 2014). Egypt also presented some of their views on the TVWS in 2014 (NTRA of Egypt, 2014), recommending that commercial TVWS deployment should be postponed till the finalisation of the DSO process and following the WRC-15 to provide certainty for the operators and end users. Even in countries, which promoted TVWS such as the US, some decisions were taken that may negatively influence TVWS deployment. In particular, in 2016, the FCC has started its long awaited incentive auction of 600 MHz that is expected to evacuate 126 MHz for mobile operators (Yahoo Finance, 2016).

3. International Radio Spectrum Management Regime

The ITU-R is the administrative cooperation body responsible for setting the international regime's rules through the ITU-R Radio Regulations (RR) and the ITU-R resolutions, recommendations and reports. The RR have international treaty status and they are binding for all the ITU-R countries (Maitra, 2004). On the other hand, ITU-R recommendations do not have legal status similar to the ITU-R RR unless they are incorporated by reference in the RR (McLean Foster & Co., 2013). Dividing the spectrum according to the type of radiocommunication service and global harmonisation of spectrum allocations are the ITU historical methods to mitigate harmful interference. The ITU-R table of frequency allocation divides the frequency band into smaller bands that are allocated to more than 40 radiocommunication services (ITU-R, 2001).

Decisions related to spectrum allocation are taken during ITU-R World Radiocommunication Conference (WRC). If a country wants to protect this new use against interference, they may add a footnote to the ITU-R RR stating their particular use (Indepen, 2001). In addition to footnotes, countries can register their important frequency assignments in the ITU-R where there are two types of registration (Ryan, 2005). The first one is a priori planning which enables a guarantee of access to the spectrum where each country submits its requirements at a world or regional planning conference.

One example of a priori planning is the ITU Regional Radio Conference in 2006 (RRC-06) which planned the process of the switchover of terrestrial broadcasting services for radio and television from analogue to digital in Europe, Africa and the Middle East (Irion, 2009). The RRC-06 resulted in the Geneva-2006 (GE-06) agreement, which planned the analogue and digital broadcasting services in the bands 174-230 MHz and 470-862 MHz. The GE-06 plan determined the end of the transition period of the analogue broadcasting services in the UHF band to be 17th June 2015 (GSMA, 2012).

The second category of assignment registration is for the non-planned bands on a first come, first-served basis frequencies in the ITU-R Master International Frequency Register (MIFR). Such registration requires conformity with the ITU-R radiocommunication service allocation table and not causing harmful interference to existing assignments in other countries (Lyll, 2011).

With regard to the existence of the concept of spectrum easements in the ITU RR, there are three cases. The first case is the co-existence of primary and secondary services, as secondary services operate in the same spectrum bands with primary services without causing

interference or claiming protection against interference from primary services. For instance, underlay devices such as SRD are perceived to operate on secondary basis as mobile service (RSPG, 2011a).

The second case can be considered to be the operation on a non-interference basis according to Article 4.4 from the RR. Such article allows operating in a way that does not confirm with the ITU-R service allocation while not causing interference or claiming protection against interference to station operating according to the RR (ITU-R, 2008).

One example of that is the WLAN devices which operate on a non-protection, non-interference basis with low powers (Anker and Lemstra, 2011). These devices usually operate in what is called Industrial, Scientific and Medical (ISM) spectrum bands such as the 2400-2500 MHz and 5725-5875 MHz bands (ITU-R, 2012a). These bands are designated for ISM applications and radiocommunication services operating within these bands must accept harmful interference which may be caused by these ISM applications (ITU-R, 2012a).

The third case is sharing between WLAN, which categorized as primary mobile service according to the ITU-R RR, and the other primary services in the 5 GHz band. This was decided by WRC-03, which allocated the bands 5150-5350 MHz and 5470-5725 MHz on a primary basis to mobile service for the implementation of wireless access systems (WAS) (ITU-R, 2003b). WRC-03 agreed also on allowing sharing of the 5 GHz band between radiolocation service (radar systems) and mobile service on a primary basis upon using dynamic frequency selection (DFS)¹ and transmit power control (TPC)² to facilitate spectrum sharing (ITU-R, 2003a, ITU-R, 2011a).

In addition to the previous three forms of non-exclusive access, the ITU-R has discussed at WRC-12, under agenda item 1.19, the regulatory measures that can enable deployment of CRS (ITU-R, 2007). One of the main outcomes of the ITU-R with this regard was issuing formal definitions of CRS and SDR (ITU-R, 2009). In addition, during WRC-12, some concerns were expressed regarding interference between CRS and space, passive and safety services (RCC, 2011). Countering this, however, others argued that national regulators can set operating parameters for CRS devices through equipment authorisation requirements to ensure they will not cause interference (CITEL, 2012, CEPT, 2011). Several regional organisations called for the development of a WRC resolution to provide a framework for

¹In DFS all radio resources are available at all RLAN nodes. A node (usually a controller node or access point (AP)) can temporarily allocate a channel and the selection of a suitable channel is performed based on interference detected or certain quality criteria, e.g. received signal strength, C/I.

²For data transmission, some standards use higher power spectral density for initialisation and control the transmit power according to evaluation of the RF link quality.

guidance on the study of CRS as well as guidance regarding how the use of CRS should be administered (ASMG, 2011, ATU, 2011, APT, 2011).

Eventually, WRC-12 did not decide on any particular measure with regard to CRS, and it was recognised that CRS are technologies and not radiocommunication services. It was also agreed that the examination of the implementation and use of CRS in radiocommunication services should continue without the need for consideration in next WRCs (ITU-R, 2012b). In addition, WRC-12 recommended that any radio system implementing CRS technology should operate in accordance with the provisions of the RR, and that the use of CRS does not exempt administrators from their obligations with regard to the protection others operating in accordance with the RR (ITU-R, 2012c).

Following WRC-12, there have been some work in the ITU-R Working Party (WP) 1B to produce ITU-R report on TVWS (Chairman of Working Party 1B, 2013). In addition, TVWS has been defined in one of the ITU-R reports (ITU-R, 2011b). However, the TVWS definition is not yet formally defined by the ITU-R similar to the case of CRS and SDR (ITU-R, 2013). Furthermore, the work within the ITU-R was decided to focus more on DSA in general rather than TVWS per se in 2014 (Chairman of Working Party 1B, 2014), and then the focus changed again to be on CRS in 2015 (Chairman of Working Party 1B, 2015).

WRC-15 contained both good and bad news for TVWS. On the one hand, in some countries in Regions 2 and 3, the 470-694 MHz band was identified for IMT, which decreases the possibilities for TVWS in these countries. On the other hand, in Region 1 countries, it was decided to maintain the broadcasting service allocation status in the previous band for terrestrial broadcasting until WRC-23 (ITU-R, 2015).

With respect to the service status of TVWS, one view from CEPT is that they should operate on non-interference basis (Newlands, 2009). Besides, the US clarified during the WP 1B meetings that they are using the TVWS on non-protection, non-interference basis (Chairman of Working Party 1B, 2013). Moreover, concepts such as license shared access (LSA) are perceived to operate according to the RR service allocation (RSPG, 2011a).

4. Methodology

A qualitative methodology is adopted for this paper that utilises an inductive approach where the theory is developed from the observations or the findings of the research (Bryman and Bell, 2007). The paper is based mainly on primary data collected from 84 semi-structured interviews with the main stakeholders from TVWS industry, national regulators,

broadcasters, and mobile industry. The paper also draws on secondary data illustrating the relevant ITU-R publications on the issue.

The second step after conducting the interviews was data reduction, which is the process of selecting and simplifying the data included in the interviews transcription (Miles and Huberman, 1994). Data reduction has been achieved in this paper through coding, which is defined as breaking data down into component parts which are given names (Bryman and Bell, 2007).

Coding is used to link data to ideas and also to find out links between the different ideas (Bazeley, 2007). A software called NVivo was used for this purpose in order to identify the important themes (Bazeley, 2007), where the final version of the transcription of the interviews was imported into NVivo as MS Word files.

The third step was data display in order to present the information systematically to drive valid conclusions (Miles and Huberman, 1994). The display type used for this paper is conceptually ordered network display where display is ordered by concepts. While there are several formats for such type of network display, this paper adopts the graphical representation of ‘cognitive mapping’ that is a causal based mapping technique that is used mainly to represent the subjective world of interviewees (Eden, 2004).

A program called ‘Decision Explorer’ was chosen for the data display that is designed specifically to support cognitive mapping (Banxia Software, 2014). For reasons of simplicity, the researcher adapted three types of styles for displaying concepts as shown in Figure 1.

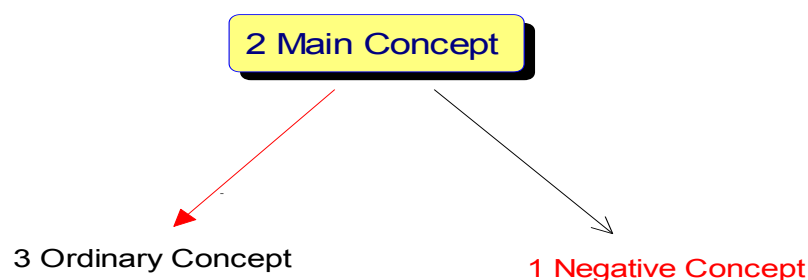


Figure 1: Link and Concepts Styles

In Figure 1, Concept 1 is called a negative concept where interviewees perceive such concept adversely or unfavourably. Concept 2 is a main or key concept that was identified

during the data analysis while Concept 3 is a typical or normal concept. The black arrow represents a causal links of being related or leading to. On the other hand, the red arrow with the negative sign implies negative relationship or link (e.g., decreases, negatively influences). It should be noted that Decision Explorer automatically creates a numbering system that does not convey specific meaning.

5. Interaction between International Regime and National Policies regarding TVWS

In this section, the paper addresses whether the international spectrum management regime accommodates the concept of TVWS without constraints. In general, the interviews revealed two views.

The first is that there is no contradiction between opportunistic access in general and the ITU-R RR, and that the later can accommodate the former without any restriction. In particular, TVWS is a national issue and the RR are flexible as long as a country does not cause interference to its neighbours. ITU-R is neutral towards technologies, and only concerned with radiocommunication services. The opportunistic access concept per se is not a service and, therefore, it can be utilised by different services.

It was also explained by one of the interviewees that there is no need for the RR in the case of the TVWS concept because it is not a cross-border issue. In particular, TVWS can operate under the provisions of ITU-R Article 4.4, as the ITU does not recognise unlicensed devices. In his words “*opportunistic access is exactly the opposite of RR, is do whatever you want if you do not create a difference in the country*”. One other interviewee clarified that the RR are well established and that many national spectrum regulations are based on them. Thus it is not expected that the technology development will dictate real changes of the RR. Hence, there is no action needed from the ITU-R to introduce TVWS. Furthermore, there is a perception that the ITU-R focuses on primary services of high power-high tower between countries, which is different to the case of TVWS. More specifically, opportunistic access would imply operating with low power to avoid interference with other services around it. Therefore, TVWS is not related to the RR, which focus on avoiding harmful interference between countries.

It was also argued that the paradigm created by the ITU is sharing rather than exclusivity from the early days wireless communication, where there were three categories of sharing access namely, primary and secondary and permitted where permitted is the category of unlicensed use in ITU regulations. As explained in this quote “*from the very beginning there was understanding that spectrum had to be shared*”. It was also explained that while

some parts of the RR urge the licensing of radio, other parts allow unlicensed use as long as it is not causing interference with licensed operations.

On the other hand, there was a view that there are some cases of restriction from the ITU-R RR on TVWS deployment. More importantly, it was stressed by some interviewees on the importance of having a service allocation in the RR in which these TVWS devices can operate. In particular, equipment using cognitive radio techniques can operate consistently with the given radiocommunication service that is already allocated in the RR. As expressed by one of the interviewees “*you would use the cognitive capabilities in order to enhance the existing service. If it is a completely different service, then you might run into problems: regulatory in the sense of having an allocation or not*”.

Furthermore, having additional mobile allocation in the UHF band in the future will make less room for TVWS. Besides, one of the issues that may delay deployment of TVWS is that many countries have not yet finalised the digital switchover process, as the deadline set by the RRC-06 conference is 2015 for the UHF band for many countries. Therefore, these countries are still waiting to finalise the transition before considering TVWS. Figure 2 below is a display of the different perceptions in the format of causal map.

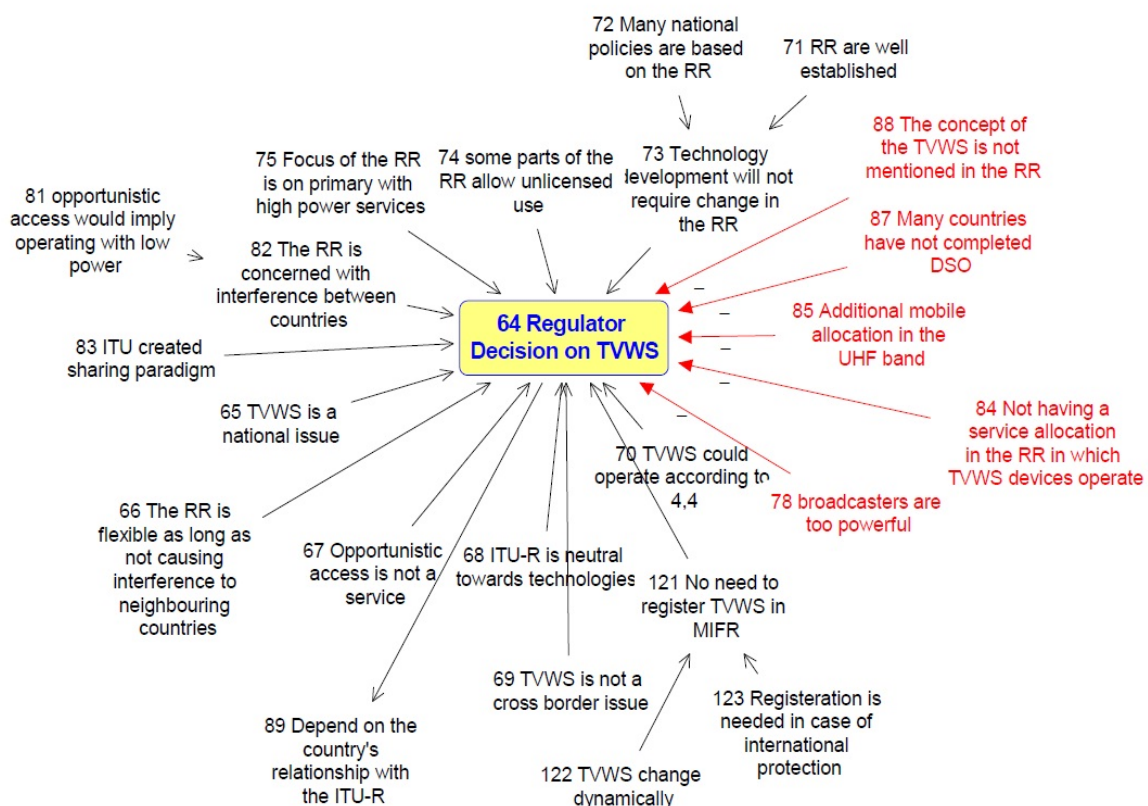


Figure 2: Interaction between International Regime and National Spectrum Policy regarding TVWS

The analysis of the causal map of the interviewees' perceptions on the issue in Figure 2 reveals that the interaction between the international regime and national policies combines elements of restriction and flexibility. More specifically, elements of restriction include concept 84, which addresses the issue of having service allocation where TVWS devices can operate, and concept 85, which addresses the influence of having additional mobile allocation in the UHF band on TVWS. The map shows that a priori planning can negatively influence TVWS deployment (concepts 87 and 79). Concept 121 shows that MIFR does not restrict TVWS, as there is no need for such registration.

In addition, the ITU-R is neutral towards technologies and, therefore, technology development does not require changes in the RR. TVWS can operate on non-interference basis according to the ITU-R Article 4.4. Finally, concept 74 tackles the assignment elements of the international regime, and it is considered as a flexible element towards TVWS deployment where the RR allow unlicensed use. Other general elements of restriction or flexibility are regarding whether TVWS should be included in the RR (Concepts 88, 82, 65, 66, 69). However, this was perceived to be dependent on the country, its relationship with its neighbours, and its perception on the TVWS concept (Concept 89).

One specific issue was raised during the interviews, namely, the issue of registering TVWS assignments in the MIFR and whether such registration could restrict TVWS. It was argued by several interviewees that there is no need for such registration for the following reasons. Firstly, TVWS devices can change too often due to its dynamic nature and, therefore, they cannot be registered. Secondly, registering assignment is only needed in case that international protection is required which is not the case of TVWS. In particular, one other interviewee explained that SDR and similar applications are never registered in the MIFR. This is due to the fact that they do not have the potential of causing interference across the borders, which justifies this sort of status registration.

One interesting point that was raised by one interviewee is that TVWS needs to have information on the use of frequencies by other stations, which can be queried through the ITU-R MIFR. In other words, as TVWS devices can use a database to identify vacant frequencies in the UHF and the band usage in general, the MIFR can indicate such information as it accommodates information on the use of the different bands.

It could be concluded that the international spectrum management regime does not prevent deploying TVWS. However, the interaction between the international regime and national regulators' decisions regarding the deployment of opportunistic access in the TVWS combine elements of restriction and flexibility as well. These elements can influence

negatively or positively such deployment. In particular, these elements of restriction are related mainly to the service allocation elements of the international regime and in particular the a priori planning concept, MIFR, and decision making procedures. Meanwhile, the interaction is mostly influenced by countries' perception on the TVWS concept and relationship with the ITU-R.

6. TVWS Radiocommunication Service Status

One point that needs to be examined is the radiocommunication service allocation status of the TVWS devices and whether they would operate on a primary, secondary, or non-interference basis. The interviews revealed four views on the service status of TVWS devices.

The first view was that it should be based on secondary basis for the following reasons. Firstly, the UHF band is quite valuable with its propagation characteristics to be allocated to unlicensed devices such TVWS as a primary service. From the broadcasters perspective, TVWS should operate on a secondary basis because operating as a secondary service and having a license would imply control from the regulator. On the contrary, if it operates similar to Wi-Fi in an unlicensed way, such control would be difficult to be implemented.

Secondly, there is a need to provide protection to the broadcasting service and not claim protection against interference. Thirdly, one interviewee explained that the GE-06 plan does not allow having another co-primary service. This is because in some cases, there are deployed TV networks for several years, and, therefore, introducing another service would mean re-planning the broadcasting frequencies. This is the reason why TVWS can only operate on a secondary basis.

Additionally, most of the views from the interviewees from the mobile industry supported having secondary status for TVWS, as TVWS devices have low power and because the ITU-R is only concerned with issues at border areas. As expressed by one of the interviewees “*secondary, definitely, the only reason broadcasters can listen to you talking about TVWS is because they’re secondary*”. Other reasons for having a secondary status for TVWS includes giving TVWS some protection against other secondary services that may be allocated later on in the UHF band. More specifically, when two services are allocated in the same spectrum band in the RR on the same basis (primary or secondary), priority is given to the firstly allocated service.

The second view is that TVWS can operate on a non-interference and non-protection basis according to the ITU-R Article 4.4 for different reasons. As expressed by this quote “*it is not secondary, it is below secondary, you cannot cause interference to secondary services*”. The first reason is to wait until TVWS has a clear definition according to the RR, as even stations of a secondary service have a definition in the RR. Secondly, it was further explained that while operating these devices you cannot seek protection from neighbouring countries, and they are used in low power applications. Thirdly, because TVWS work in an opportunistic way, there is no implication on their radiocommunication service status. This is because it becomes a matter for the national regulator to ensure that these applications are not causing interference.

Another view is that from the international regulation's point of view, there is no status, because these TVWS systems are not mentioned in the RR. In addition, it was clarified that an allocation in the RR is only needed in case of protection requirement for such application on the international level. It was also argued that TVWS is a national decision, which is an optimum solution especially if there is no existing allocation where TVWS can operate. In other words, in case a country does not have a service allocation in the RR where TVWS devices can operate (e.g., secondary mobile allocation), these devices can operate on non-interference basis.

The third view is that TVWS should operate on a primary basis. This is because not all of the UHF band is used for broadcasting. However, this primary status can be under some restriction to protect the broadcasting service so that it would have a primary status with a secondary priority to the broadcasting service. It was further clarified that secondary status for TVWS will not make its application effective. This is the main reason why these applications should be primary to have some priority in their work especially from neighbouring countries. One interviewee explains that if TVWS operate on a secondary basis, it would be valueless. In the interviewee's words “*you are selling nothing and nobody will take it*”.

The fourth view is that the TVWS status is related to a national decision on what type of system is using those TVWS devices. In particular, it was clarified that service status is not related to the concept of opportunistic access, and that some status depends on the spectrum bands. Therefore, TVWS can be primary or secondary according to the status of the band, and also according to national laws and the definition of TVWS. In other words, the national status of these devices is independent from the international status.

As expressed by one interviewee “in national licensing, the TVWS could be primary but you'll have to protect the broadcasting, so this status in the RR does not say anything about the status on national bases...people are mixing up the national decisions with the international decisions”. Another interviewee made a link between the issue of not registering TVWS devices in the MIFR and the freedom regulators have regarding TVWS service status on the national level. In the interviewee’s words “if it is not registered in the MIFR, it is up to national regulator to think of a primary or secondary status”. The previous four views are displayed in Figure 3.

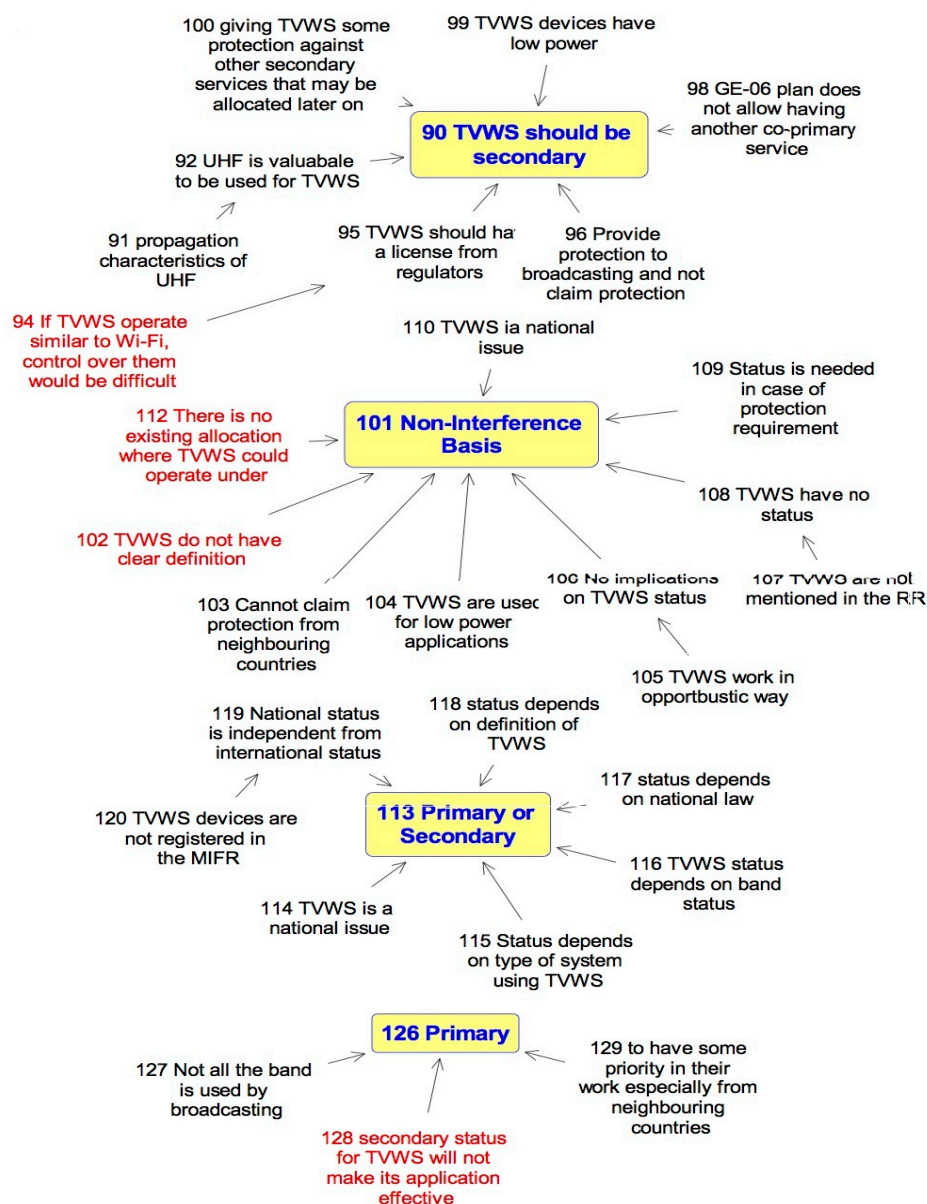


Figure 3: Interviewees’ Perception on TVWS Service Status

The analysis of the causal map of the international interviewees on the TVWS service status in Figure 3 shows that the status perception is related to the perception on the TVWS operation and application. Firstly, regarding the perception of TVWS status as secondary service, concept 100 reveals that having a secondary service is a plus for TVWS devices, as it provides protection against other secondary services that may be allocated in the future. Moreover, concepts 96 and 98 show that a secondary service is essential but does not negatively influence the a priori planning of the broadcasting service in the UHF band.

On the contrary, concepts 99 and 92 highlight the perception on TVWS devices as not critical applications. In addition, concept 95 reveals an interesting point that having a status is important for regulators in order to have control over wireless devices. Furthermore, concept 119 conceals an interesting perception, which is that countries are free to have different service priorities than those outlined in the RR.

Regarding the operation of TVWS on a non-interference basis, concepts 102 and 108 reflect the view of the prematurity of TVWS and their absence from the RR. Concepts 103, 104, 106, 109, and 110 show the perception of some of the international interviewees on the operation of TVWS as low power applications that do not need protection and work in an opportunistic way nationally. Concept 112 shows that non-interference basis is a second option in cases where there is no allocation where TVWS devices can operate within (e.g., mobile).

With respect to the case of having a status depending on the situation, it was revealed that service status is a national decision according to a country's perception on TVWS, its internal circumstances, and the band status in this particular country. Primary status is perceived important to empower TVWS devices against other co-primary services (concept 129), especially when there is no much use of the broadcasting service (concept 127).

These findings highlight that there are four different perceptions from the interviewees on the TVWS devices radiocommunication service status, namely, secondary, non-interference basis, primary, or primary or secondary according to the perceived operation of these devices.

7. Perception on the WRC-12 Agenda Item 1.19

This section focuses on the discussion related to WRC-12 A.I. 1.19, which relates to the regulatory measures to introduce CRS and SDR. This is important as both technologies can be used for the concept of opportunistic access in general or for the case of TVWS specifically.

Regarding the discussion over A.I. 1.19 during WRC-12, it was explained by one of the interviewees that the debate at the WRC-12 was between non-European countries, which wanted to have a resolution in the RR, and between the European countries and the US who called for a resolution from the Radio Assembly of 2012 (RA-12) to call for further study³. One of the interviewees who was involved in the discussion on A.I. 1.19 before WRC-12 explained that the reason for not having a WRC resolution on CRS was that there were no sufficient studies of the issue. Instead, the WP1B only managed to put definitions for CRS and SDR. Therefore, it was perceived premature to have a resolution on CRS with one interviewee stating “*imagine that you still define something, and you want me to give you a resolution! About what?*”.

It was also clarified that during WRC-12 some countries had concerns relating to interference from these systems. Eventually, everyone agreed that further study is needed, which was addressed by the ITU-R resolution 58 from the RA-12. Moreover, the WRC-12 recommendation showed that CRS should follow the RR, and it was a compromise that everybody was happy with.

Regarding the influence of the WRC-12 decision on A.I. 1.19 on TVWS adoption, the analysis of the interviews shows three distinct views. The first view was that the decision does not encourage nor restrict the TVWS concept adoption because implementation of such concept can be accommodated within the current RR without any modification, as it is a national issue. It was further explained that the RR is a relationship between countries, and opportunistic access is mainly a problem of protection within a country between different usages. Moreover, CRS and SDR are already deployed in mobile cellular technologies.

In addition, the decision does not restrict implementing TVWS, and there should not be any regulation on CRS because it is just a radio, which is able to adapt itself to the regulation that prevails in each frequency band. In an interviewee’s words “*cognitive radio is something which adapts itself to the RR and not the opposite*”. It was also argued that the A.I. 1.19 was of a concern to countries that have a high level of mobile phone development and are examining how the sector may develop in future. On the other hand, the developing countries did not have specific interest during the conference. Therefore, there was no need to take a specific position.

The second view is that such a decision of the WRC-12 on A.I. 1.19 can be considered as encouragement for TVWS adoption, because CRS is one of the ways to implement and use the TVWS, and to introduce opportunistic access in general. More

³ Unlike WRC resolution, RA resolutions are not binding.

specifically, the decision was a good outcome because it provided a definition for CRS and SDR, it did not stop opportunistic access and it did recognise rather than restrict CRS and SDR.

The decision was also perceived to give the developer of the technology a bit of leverage over regulators who are not knowledgeable. Additionally, at least the RR did not put barriers and it gave recognition to CRS and DSA and that the RR accommodate them. As expressed by this quote *“the alternative could be that ITU could have just said that we are not ready, and we do not want to discuss it anymore”*. Therefore, it was perceived that the WRC-12 decision to be a good outcome for the industry of TVWS.

The third view is that the decision can be considered as discouragement. Firstly, the decision to have further study could lead to the postponement of the issue as administrations will would adopt it because there are current studies in the ITU. Additionally, one view was that encouragement could be in the form of setting aside band for CRS.

It is worth mentioning that the analysis also showed that the influence of the decision depends more on the regulators themselves. In particular, interviewees from some developed countries explain that their regulators consider that unless the RR explicitly said you cannot do something, then you can go ahead and do it. On the other hand, for some other countries, until it is mentioned in the RR, they cannot implement it. In particular, some countries tend to be more conservative and will need some further clarification from the ITU, and for these countries, the WRC-12 decision on CRS could be considered as a non-decision rather than a decision. As expressed in this quote *“they’re going to wait for ITU to say something more definitive”*.

This is quite apparent in the case of the developing countries, which like the idea of international regulations authorising national regulations. As clarified by one of the interviewees, these countries adopt the authoritarian tradition⁴ where nothing is allowed unless the state specifically authorises it. Therefore, for these countries, the TVWS concept is not allowed as it is not covered in the RR.

On the contrary, in some countries, which follow liberal traditions such as the US, everything is allowed unless the state specifically forbids. He further clarified that radio regulations have been traditionally following the authoritarian law as opposed to liberal law since the early days of radio when liberalism was not an acceptable option in the rivalry between the major powers. The previous different views are presented in Figure 4.

⁴Authoritarianism is a form of government characterised by absolute, unquestioning or blind obedience to authority, as opposed to a form of government characterised by individual freedom.

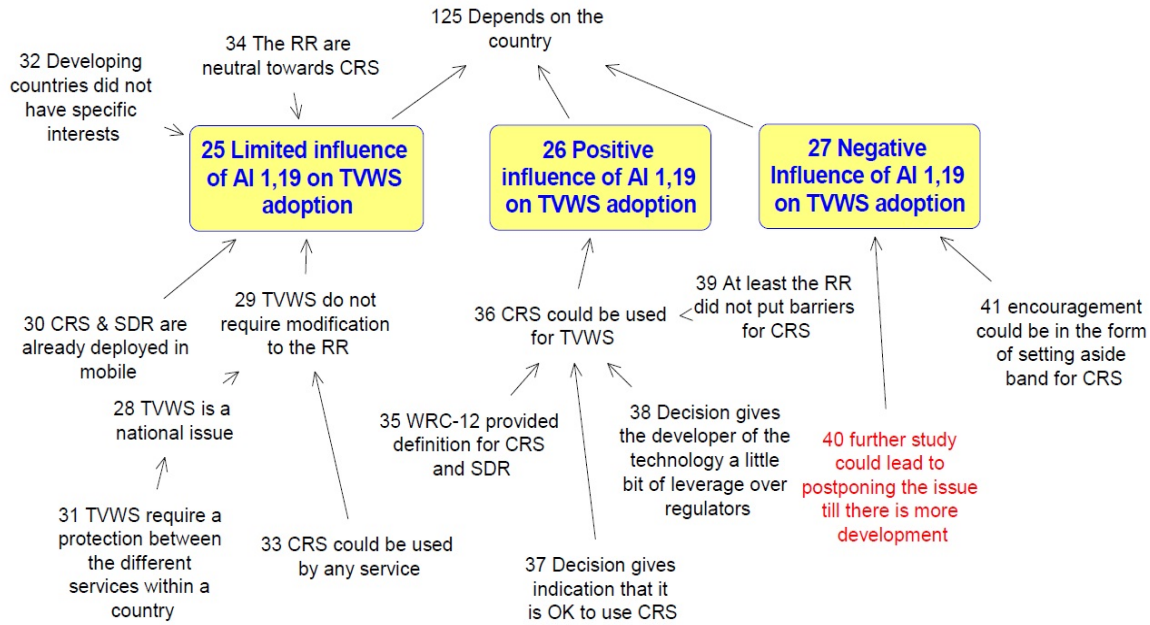


Figure 4: Interviewees' Perception on the Influence of WRC-12 Decision on A.I. 1.19

The analysis of Figure 4 on the influence of WRC-12 decision on A.I. 1.19 on the TVWS concept reflects the different expectations of the interviewees from the ITU-R. In particular, for some, the decision was not enough to boost TVWS deployment (concepts 40 and 41). On the other hand, others perceived the decision, as indirect support to CRS (concepts 35, 37, 38 and 39), which can be used for TVWS deployment (concept 36). The third view is a reflection of the perception of the neutral position of the ITU-R towards CRS and TVWS. In addition, it is related to the lack of interest of some countries in the discussion on A.I. 1.19 during WRC-12. Additionally, the influence depends in general on the countries' relationship with the ITU-R (concept 125). It can be concluded that there are three different perceptions on the influence of WRC-12 decision on A.I. 1.19 on TVWS adoption from the perspectives of the international interviewees, namely, limited, positive, and negative. Meanwhile, the influence is mostly influenced by a country's relationship with the ITU-R.

One emerging issue that was discussed during the interviews is the need to have a particular ITU-R resolution or decision with regard to the TVWS in the future considering the WRC-12 decision on A.I. 1.19. Analysing the interviews revealed two views. The first is that such a resolution would be useful as many administrations follow the ITU, and because the ITU regulations would help narrow the variation between countries that exists in terms of regulations. Another important consequence of such a resolution is having an obligation on countries to coordinate with its neighbours regarding these TVWS devices operations.

The second view is that there is no need to change the RR but rather to use the ITU to provide guidance to national regulatory authorities through a voluntary recommendation or report as it is not a matter of radiocommunication service allocation. In addition, one interviewee from the TVWS industry explained that the ITU should develop a set of standards that can be applied in any band where sharing is considered rather than creating particular regulations for the case of TVWS. One other interviewee explained that such a resolution would be specific to the UHF band, though CRS cannot be band specific.

There was also a view that if TVWS concept is in the RR, this would be restrictive as the technology tends to evolve. As expressed by one of the interviewees *“you could end up with all kind of things that you do not want”*. Moreover, special rules in the RR may slow down the development of TVWS technologies as suggested by the following quote *“the dangers with modifying the RR are relatively inflexible and slow to change, and if you can introduce them without that then that is probably quicker”*. Furthermore, introducing changes to the current international framework will take time due to the resistance from other stakeholders.

8. Comparison with The Case of WLAN in The 5 GHz Band

While this paper focuses on the issue of opportunistic access in the TVWS in the UHF band, it was inevitable that the interviews would also address the case of having mobile allocation in the 5 GHz band for the application of WLAN that was approved at WRC-03. This was for the purpose of comparing the international regulatory measures required for the TVWS with these special ones already adopted for the use of WLAN in the 5 GHz as previously explained.

In particular, several interviewees commented on why the ITU-R decided some regulatory measures for the case of WLAN in the 5 GHz in the WRC-03 unlike the case of CRS in WRC-12. It was highlighted during the interviews that mobile allocation in the 5 GHz was for the first time to associate unlicensed use (permitted application) with a status of a radiocommunication service (mobile). Therefore, it was important to examine whether the interviewees think a similar approach is needed for the TVWS.

One interviewee who was closely involved in the issue during WRC-03 explained that the idea was not to place WLAN under a mobile or fixed service because the difference between the two services is blurring. Instead, the main aim was the global harmonisation of the band. It was also clarified that the allocation aimed to give more certainties for the band users for the future in case of potential allocations in the band. The band had already at the

time of the WRC-03 several existing primary allocations so that WLAN was given a primary status but on a secondary priority compared to these existing allocations.

The analysis of the interviewees showed two different views on whether such measures are needed for TVWS. One view was that having similar measures might not be needed for the TVWS case for several reasons. Firstly, the TVWS issue is not clear and still emerging. 5 GHz was a special case that is needed for the development of a global market in a similar way to IMT identification. In particular, unlike the case of the WLAN, the TVWS has not yet a clear global market as it is specified by some countries for rural broadband coverage which is already provided by mobile at lower cost. Therefore, what could be needed in the case of TVWS is a recommendation that allows administrations to negotiate on the border.

Secondly, the use of DFS was related to sharing complications between radar systems and WLAN in order to ensure that they can co-exist. One interviewee explained that a key difference between the TVWS and the WLAN in the 5 GHz is that the latter utilised bands where there are operations by satellite services so that it is not enough to obtain agreement with neighbouring countries. This is in contrast to TVWS devices that operate in bands used only by terrestrial services and, therefore, interference can be resolved largely in border areas.

One interviewee explained that until there is a mobile allocation in the band where TVWS devices can operate, TVWS cannot have similar measures and should operate according to the RR Article 4.4 that cannot have associated conditions. One other view was that there is no need to place such detail in the RR. It was also expressed that the TVWS concept in the UHF band is perceived as a short-term solution. One point that was clarified is that DFS has shortcomings as it has limited ability to adapt in the future. Therefore, if TVWS devices radios are querying a database for policy instead of adopting DFS, they can adapt over time to work with new versions of radar or other technologies in that band.

The second view suggested that having similar measures for the case of TVWS would achieve economies of scales, reduce the cost of the equipment, and give strong directions to the industry that these frequencies are secured to develop this specific service. As expressed by one interviewee *“it would be helpful to the ITU to say that you can have opportunistic access to TV bands, and here are the mechanisms we recommend”*. This was confirmed by one interviewee from the TVWS industry who thought that such a decision would improve the TVWS ecosystem because the more consistent the use and availability of bands around the world, the more investment radio providers will put into it. Figure 5 shows how these different perceptions relate to one another.

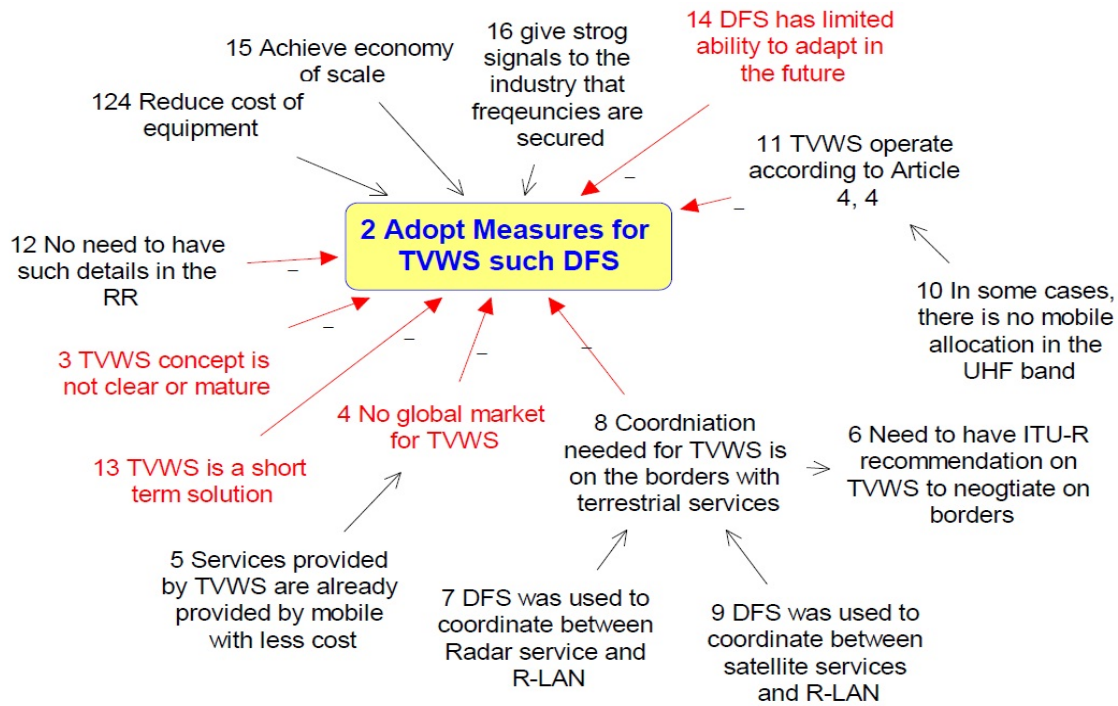


Figure 5: Perceptions on the Need to Adopt Measures for TVWS such as DFS

The analysis of the causal map in Figure 5 of the interviewees' perspectives shows that the views on having measures for TVWS such as DFS reflects the views on the concept of TVWS per se. For instance, some were of the view that such measures are not needed because of deficiencies in the TVWS concept (concepts 3, 4 and 13). Some others felt that such measures are not suitable for the operation of TVWS, which is different than the case of WLAN in different aspects. In particular, the 5 GHz band where WLAN operates needs coordination with different types of services than those operating in the UHF band (concepts 7 and 9). On the contrary, TVWS devices only need coordination on borders with terrestrial services (concepts 6 and 8).

Other views reflect deficiencies in the measures adopted for WLAN, which may restrict the concept of opportunistic access (concept 14). Moreover, concept 11 reveals the influence of service status of TVWS on the need for regulatory measures similar to the case of WLAN. On the other hand, concepts (15, 16, and 124) show the perception that those measures used for WLAN in the 5 GHz can enable similar success and wide adoption for the case of TVWS.

One point that was raised during the interviews is whether there is a need to have a dedicated band for TVWS operation similar to the case of ISM bands where WLAN operates on non-interference basis. One interviewee explained that communications is not allowed in the ISM bands because these bands are used for devices that emit radio as noise such as

microwave ovens. In addition, ISM applications are using the spectrum for non-communications, and therefore, they do not need protection from interference. As expressed by one of the interviewees “*you cannot cause interference to something is not communicating*”.

Furthermore, it was clarified that when the FCC decided to use the ISM bands for communications via spread spectrum, the ITU opposed allowing communications in these bands as a matter of principle. One other interviewee expressed that ISM bands are recognised in the RR while the TVWS concept is not yet. In addition, it was pointed out that the danger of providing dedicated bands for TVWS is that it might be seen as excluding TVWS from other spectrum bands.

9. Conclusions

This paper has addressed the question of ‘how does the international radio spectrum management regime influence the adoption of opportunistic access in the TVWS?’. The examination of such question shows that the international regime does not prevent adopting opportunistic access in the TVWS. However, there are different elements of flexibility (support) and restriction (opposing) that have an influence on a regulator’s decision regarding the deployment of such a concept. These elements are dependent on a country’s relationship with its neighbouring countries, perception of the TVWS concept and the interpretation of the international regulations. Restrictive elements include not having a service allocation where TVWS devices can operate, having additional mobile allocation and the a priori planning of the broadcasting service in the UHF band. On the other hand, TVWS can operate on a non-interference basis according to the ITU-R article 4.4, and unlicensed operation is allowed by the RR on the condition of not causing interference.

There are four different perceptions of the TVWS service status: secondary status, non-interference basis, primary, or primary or secondary according to the perceived operation of TVWS. The first view is that the operation of TVWS on a non-interference basis reflects the views of the immaturity of TVWS. The second view is that non-interference is considered to be a second option in cases where there is no allocation where TVWS devices can operate within. The third view is that primary status is needed to empower these TVWS devices. The fourth view is that the service status is a national decision according to a country’s perception of TVWS, its internal circumstances and the band status in this particular country.

There are three different perceptions on the influence of WRC-12 decision on A.I. 1.19 on TVWS adoption: limited, positive and negative. Meanwhile, the influence is mostly

influenced by a country's relationship with the ITU-R. Regarding the need to have a particular ITU-R resolution regarding TVWS in the future there were two views. The first is that such a resolution would be useful as many administrations follow the ITU, whereas the second view is that there is no need to change the RR but rather to use the ITU to provide guidance to national regulatory authorities.

There are two distinct views on the need for similar measures being adopted in the case of WLAN in the 5 GHz for TVWS such as DFS based on the perception of TVWS service status, deficiencies of TVWS, deficiencies of DFS, differences between operation of WLAN and TVWS, and positive influence of such measures on the TVWS adoption.

Through our analysis this paper has revealed the perceptions among stakeholders that the TVWS concept is still not mature enough to receive supportive measures from the ITU-R. These measures do exist in several cases although the ITU-R is supposed to be neutral regarding different technologies. In addition, the different views on the TVWS radiocommunication service status reflect the diversity of the way the TVWS concept is expected to operate.

Furthermore, a large part of the concerns related to the concept of opportunistic access in the TVWS is related to the UHF band where they operate rather than to the concept per se. Therefore, the opposition to the TVWS concept does not imply the refusal of the opportunistic access concept in general. Instead, the deployment of such concept should focus on other spectrum bands, preferably higher bands, where there are no incumbent users.

Moreover, it is argued that TVWS proponents were quite unlucky in terms of the timing of deploying such concept. More specifically, the TVWS concept may have had a better chance if it was launched before the RRC-06 conference when analogue terrestrial broadcasting was well established around the world. However, the consecutive mobile allocations in the 800 MHz and 700 MHz spectrum bands by the WRC-07 and WRC-12 respectively have reduced significantly the TVWS chances in the whole UHF band. Such allocations have also threatened broadcasting operations so that they were quite reluctant to allow any operations in the already reduced frequencies in the UHF band.

In addition, the current discussions on TVWS in the ITU-R have reflected the absence of a strong lobby from industry supporting the concept and calling for additional enabler measures from the international regime. There is still a chance for the TVWS industry to call for an agenda item in future WRCS (e.g., at WRC-18) to have a supportive decision on the concept on the condition that there is consensus on that from ITU-R member states.

Moreover, this paper has shown that there are different interpretations to the RR that reflects a country's perceptions of the international regime and whether the ITU-R rules are mandatory or voluntary. This was also quite apparent in the issue of the influence of WRC-12 decision on A.I. 1.19.

Finally, it seems that promising technologies of opportunistic access are not able yet to encourage national regulators to adopt concepts such as TVWS similar to what happened with Wi-Fi. While regulators may be able to resist innovative ideas of spectrum management, technologies it is argued here are the drivers for any potential change. In other words, until the technologies of the TVWS concept are mature enough and achieve economies of scale, regulators may not allow such opportunistic access techniques.

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