Analysis of ICASA Broadcasting Frequency Plan for Possible use of TV White Spaces for Broadband Access

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Abstract- Television white spaces (TVWS) are unused portion of TV spectrum as a result of analogue TV coverage planning and the migration to digital terrestrial TV (DTT). As a member of the International Telecommunications (ITU) Region 1, South African regulator, the Independent Communications Authority of South Africa (ICASA) released the terrestrial broadcasting frequency plan published in April 2013. The ITU 2006 Regional Radiocommunication conference and the South African Department of Communications policy on digital TV migration formed the basis of the TBFP-2013. In this paper, we present the South African TV broadcast market and then analyse the impact of TBFP-2013 on TVWS networks operating on licence-exempt basis towards the cellular network operators. Key contribution of this paper is to highlight South African policies and regulations around the use of TVWS networks in the post digital switch over period which is set to commence after June 2015.

Index Terms—Rural areas, TV white spaces, ICT, radio frequency, spectrum, regulation, policies.

I. INTRODUCTION

The ever growing global demand for mobile and wireless broadband applications and services is a key driver behind the radio frequency (RF) spectrum reforms being proposed and undertaken in the US, EU, Asia and Africa. Traditional spectrum regulation and management rules, such as the command and control with their respective spectrum allocation techniques (exclusive licensing and common rights or license-exempt) need to be reviewed to allow more efficient spectrum utilization [1]. With the looming deadline for South Africa, June 2015 and June 2020 for other countries [2], for the global migration of television (TV) broadcast from analogue to digital, regulators around the world are looking for appropriate regulatory solutions to make use of the TV white spaces (TVWS) to benefit their society, especially to accelerate the broadband connectivity of rural areas to the internet [3,4]. The use of TVWS wireless broadband technology promises to close the digital divide gap that exists between the urban and rural areas by providing affordable wireless broadband communications to rural areas. Recent studies by the ITU found that broadband penetration in rural and semi-urban areas is very low due to, among others, lack of infrastructure and investment by incumbent operators due to the low average revenue per user (ARPU), typical of such regions [5].

Recent advancements in wireless technologies allow efficient sharing of RF spectrum through dynamic access in time, frequency and space dimensions [6]. Some of these advancements include spectrum sensing using cognitive radios (CR) [7], and the use of geo-location database (GLDB) for spectrum sharing with licensed or primary users [8]. The technique which is mature enough to be implemented such as the use of GLDB for TVWS access [3,4,] also promise low interference to primary users and network reliability. While other techniques are under intensive R&D investigations, one of these is spectrum sensing in CR technology [6,8], which in a mature state will usher a true CR technology in heterogeneous next generation wireless broadband networks. However, the success of these techniques for DSA in South Africa will rely on local policies and regulations which need to be aligned to the ITU Region 1 countries. This includes the development of new or updated broadcasting frequency plan in order to release some of the TV spectrum for non-broadcasting services, which is in line with the International Telecommunications Union (ITU) Regional Radiocommunications conference of 2006, which is widely known as RRC-06 [2].

In South Africa, the Department of Communications (DoC) is responsible for developing the information communications and technology (ICT) policies, which are implemented and regulated by the Independent Communications Authority of South Africa (ICASA). In 2008, the DoC released the *broadcasting digital migration policy*, which was amended in 2012 [9]. The aim of the broadcasting digital migration policy is to set the parameters and guidelines for migrating the country's analogue broadcasting (both audio and TV) from analogue to digital. These policies were then used by ICASA to develop the digital migration regulations [10] and the terrestrial broadcasting frequency plan-2013 (TBFP-2013) [11]. These documents, DoC broadcasting digital migration policy, ICASA digital migration regulations and TBFP-2013 are analysed in this paper with the aim of highlighting the progress made by South Africa toward TV digital switch over (DSO), and ultimately the plan to use TVWS networks for wireless broadband internet service provision in rural underserved areas..

The main contributions of this paper includes: presentation of RF regulation hierarchy, study of key parameters of South African TV DSO policies and regulations, and the analysis of ICASA TBFP-2013. Finally, we present the cellular operators concerns on the approach of allowing licence-exempt access to TVWS for provision of cellular-like services.

The rest of this paper is arranged as follows. Section II presents current RF regulations and the availability of

TVWS in South Africa. The migration policy of South Africa and TBFP-2013 are analysed in Section III. Section IV studies the cellular operators' perspective of licence-exempt operation of TVWS and the possible TVWS network models for rural communities. The paper is concluded in Section V.

II. RF Regulation and TVWS In South Africa

In this section a typical rural settlement such as a village is briefly presented in the context of the location from the city, the infrastructure and TV coverage.

A. RF Regulation Hierarchy in Southern Africa

Generally, RF spectrum regulation in every country is the responsibility of the government agencies, such as ICASA in South Africa. This setup is true for all countries under the ITU-Radio (ITU-R) Regions. Figure 1 illustrates the regulatory hierarchy from the national level (such as ICASA) to the ITU world level. ICASA is shown in the figure as an example of a national regulator, and can be replaced by any other Southern African Development Community (SADC) member states regulator like Zambia Information and Communications Technology Authority (ZICTA). From the national level, spectrum regulation is handled at the regional level to ensure harmonization.

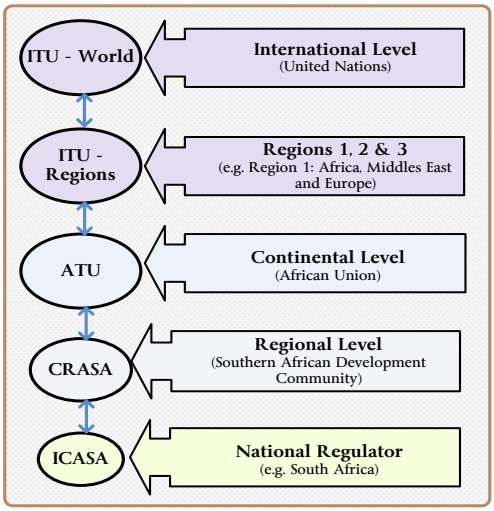

Figure 1: RF Spectrum and ICT Regulation Hierarchy from National to ITU Level

The Communications Regulators' Association of Southern Africa (CRASA) is the regional regulator in the SADC region. CRASA is responsible of facilitating the development and harmonisation of policies and regulations within the SADC region.From the regional level, regulation decisions are now taken at the continental level, such as the African Telecommunications Union (ATU). The ITU-R Regions are the next level on the hierarchy for RF regulation decision. This normally takes place during the ITU - RRC, and Africa falls under the ITU Region 1 with Europe and Middles East. Finally, the entire world RF spectrum regulation decisions are taken at the ITU-World during the World Radiocommunications Conferences (WRC), which are held every three to four years in Geneva. The goal of the ITU-WRC is to "review and revise the radio regulations, international treaty governing the use of the RF spectrum and the geostationary-satellite and non-geostationary-satellite orbits" [2]. Therefore, the ITU-WRC outcomes are important to allow world-wide interoperability of ICT equipment.

In developing countries, where national spectrum regulators are less resourced and are limited to do their own research supported assessment of the ITU regulatory decisions, ITU-RRC and WRC spectrum regulatory decisions are normally implemented as is, without any modifications. While this approach is important for international and national harmonization, it leaves the developing countries lagging when it comes to the deployments of new technologies. They either have to wait for other regional members to decide on technology and regulation, and then follow-suits. A very recent example is the current migration of TV from analogue to digital broadcasting. The final decision on how the SADC member countries will make use of the TVWS technology once DSO is completed is being delayed due to insufficient information.

B. TV Subscription in Southern Africa

Prior to commencement of the global digital terrestrial TV (DTT) switch over (DSO), there are two methods of receiving the TV services: free-to-air terrestrial analogue TV (ATV) and two paid digital satellite TV (DSTV) [12]. By the year 2012, the Department of Communications (DoC) estimated that there were over 11.5 million TV-owning households in South Africa [9]. About 75% of these households were receiving TV through free-to-air terrestrial ATV and the remaining 25% households subscribed to the pay DSTV [9]. Most of the pay - TV subscribers were found in the urban areas (due to economic reasons among others) and the majority of the free-to-air subscribers were in the rural areas. The introduction of the second paid DSTV services provider is expected to introduce some competition and ultimately bring the pay TV subscription down; thereby allowing households to subscribe to the paid TV.

Furthermore, the migration of the 75% free-to-air households to DTT will require an upgrade of the current ATV sets to digital TV display and set-top boxes (STBs). A study by South African Department of Communications (DoC) found that over five million TV-owning households are poor and will not be able to afford the STB [9]. It was then decided that these poor TV-owning households will be subsidised to get the STB. It is yet to be seen whether the remaining households, who can afford the STB will switch to pay – TV or buy the STB for the free-to-air DTT. Thus, the on-going DSO, the experience and impact of DTT (such as the purchase of STB) is likely to affect the mainly the rural TV-owning households than the urban TV-owning households, since the majority of urban households are already subscribing to the DSTV.

C. TVWS Availability in South Africa

Several field studies and measurements on RF spectrum occupancy within the VHF and UHF TV bands were conducted around South Africa [13] and [14]. These studies found that hundreds of MHz of RF spectrum (widely known as digital dividend) is available as a result of traditional analogue TV coverage planning; and it is estimated that the TV DSO process will free even more RF spectrum [9]–[11]. For instance, our 2011 RF spectrum occupancy measurements at three locations, Pretoria and two remote rural areas (Philipstown) in the Northern Cape, South Africa, and Macha in Zambia found that only one analogue

free-to-air TV station (SABC 2) was broadcasting in Philipstown, and the entire TV band was empty [13]. Large scale RF spectrum field measurements are being undertaken by CSIR in collaboration with industry in Cape Town and Limpopo Province as part of the TVWS trial projects. If a case of Philipstown is considered, it can then be estimated that over 400 MHz of DD spectrum is available in South African rural areas. This leads to a key question that needs to be addressed by African governments, regulators and ICT operators: *How can the regulators in the SADC region make use of TVWS spectrum to provide affordable broadband access to rural communities?* The next section presents a status of TV DSO based on the DoC policies and ICASA regulations.

III. South African TV Migration Policy and Frequency Plan of 2013

Like other countries, South Africa is going through the TV DSO process and will use the European second generation digital video broadcast – terrestrial (DVB-T2) standard with MPEG-4 compression. DVB-T2 is also proposed as a common standard for the SADC region [15].

A. TV Digital Switch Over in South Africa

The main purpose of the South African DoC broadcasting digital migration policy" (BDMP) is to "set (DoC) parameters of migrating the country's (TV and radio) broadcasting from analogue to digital" [9]. The policy gives ICASA the mandate to decide the best regulations for the use of TV spectrum and to also introduce new services and players or licenses to facilitate the development of competitive environment. Table 1 summarises key parameters and information from the DoC's BDMP.

Table 1: South African DoC Key Migration Parameters

Description	DoC Policy	Comments
DTT Switch-on date	2012 4th quarter	75% of population to be covered by 2012, 95% by 2013.
Digital TV Technology	DVB-T2 (terrestrial) & DVB-S2 (satellite)	DVB-S2 to be used in hard to reach areas
National Multiplexers	Two (2)	During dual illumination period
Mobile Digital Terrestrial TV	Two metropolitan networks	Designated frequencies for MDTT
Set-top-boxes	Allows access to e-Government services	To be manufactured in South Africa
End of Dual illumination	To be decide by Minister of DoC	Dual illumination period reduced to less than 3 years
No. of digital channels per 8 MHz TV bandwidth	16 Standard definition channels	More efficient that analogue TV
Digital Dividend (DD)	Part of DD spectrum to be used for mobile services, In line with ITU	Use of DD or TVWS to be realised after migration process

B. ICASA Digital Migration Regulation

After the release of the first BDMP by the DoC (in 2008), ICASA published the "digital migration regulations" under government gazette (No. 32956) in 2010 [10]. This regulation had four key objectives: 1) To regulate the digital migration of the ATV; 2) to prescribe the conditions for the allocation of channels capacity in the two multiplexers (MUX 1 and MUX 2); 3) to prescribe the procedure for the authorization of digital incentive channels; and 4) to set digital migration time frame for incumbent broadcasting service licensees. The ICASA digital migration regulations also established a joint spectrum advisory committee (JSAC) as a consultative forum to promote the efficient co-ordination of RF spectrum and interference resolution during the migration period. The JSAC should be dissolved six months after the dual illumination period [10].

During the same period of releasing the digital migration regulations, ICASA also released the document called "reasons document of digital migration" [16]. The aim of this reasons document was to "set out the basis for certain policy determinations" made in the digital migration regulations taking into account the submissions made by stakeholders and the DoC BDMP.

C. The Terrestrial Broadcasting Frequency Plan – 2013

In April 2013, ICASA published a general notice on the update of the terrestrial broadcasting frequency plan 2013 (TBFP-2013) [11]. The TBFP-2013 will see new players, such as mobile digital terrestrial TV (MDTT) providers, entering into the TV market once the DSO process is completed (post 2015). TBFP-2013 also addresses the terrestrial digital audio broadcasting (DAB) on the VHF band, although this band is currently occupied by the analogue TV (ATV). Thus, the VHF band also needs to be cleared to allow DAB services. While the TBFP-2013 includes both digital audio broadcasting (DAB) and DVB, the focus of this paper will be on DVB since it includes the UHF band which is being considered for digital dividend and opened for TVWS technology exploitation.

VHF Broadcasting Bands: FM Sound and TV

As a member of ITU Region 1, allocation of the VHF and UHF TV bands in South African is in accordance to the ITU-RRC 2006 [2]. The TBFP-2013 does, however, make special restriction for Astronomy services in the Northern Cape Province in order to prevent any interference to the Square Kilometre Array (SKA), the world's largest telescope in South Africa. According to the South African TBFP-2013, the VHF band consists of frequency modulation (FM) sound broadcasting and TV broadcasting. The VHF-FM band is between 87.5 and 108 MHz with 204 channels of 100 kHz bandwidth each [11]. For national FM coverage, high power transmitters are located approximately 110 km apart.

The VHF TV broadcasting band is between 174 and 238 MHz and 246 and 254 MHz, which is equivalent to 9 channels of 8 MHz bandwidth each. ICASA has approved the introduction of near instantaneously compounded audio multiplex (NICAM) on channel 13 since it is close to the public trunked mobile radio communication services [11].

UHF TV Broadcasting Bands

Prior to the TV DSO, South Africa have a total of 2, 464 frequency assessments for both analogue and digital TV.

The UHF band ranges from 470 to 854 MHz, and contains 48 channels of 8 MHz bandwidth each. These channels are arranged into 12 groups of 4 channels. Thus, 4 channels are normally assigned or available for assignment at a single transmitter site, and between 7 and 11 channels are assigned where the demand is high, especially where both UHF and VHF channels are assigned to a particular area.

Mobile Digital Terrestrial TV

In 2007, ICASA issued test license for DVB-Handheld (DVB-H) to MTN and Vodacom (which are traditional cellular providers) and Sentech (national signal distributor) to test the MDTT [11]. This action was as a result of the DoC Ministerial policy directives to introduce mobile TV services in South Africa. According to ICASA, MDTT services are to be licensed on technology neutral basis, and MDTT multiplexes (MDTT1 and MDTT2) are created to as part of the DSO process. Thus, two UHF channels are planned and reserved for MDTT in major metropolitan cities and the surrounding [17]. For instance, channels 33 and 35 are reserved for MTV in Gauteng and surroundings, channels 25 and 33 for Durban and surroundings, channels 28 and 32 for Cape Town and surroundings. This is depicted in Figure 2. Additional channels will also be added after the DSO to extend the MDTT coverage to other metropolitan areas [11]. The aim is to ensure that MDTT coverage is equivalent to the one provided by ATV.

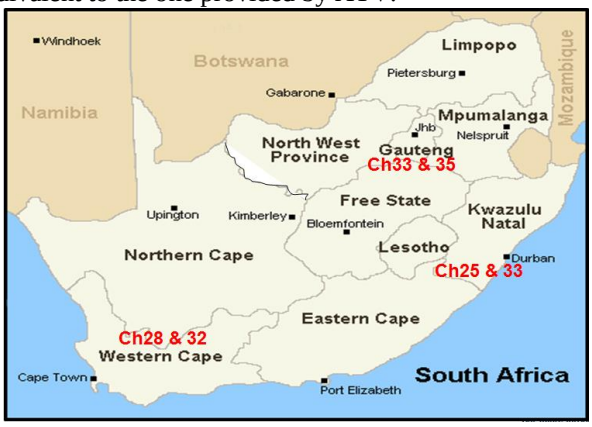

Figure 2: Mobile TV Channels reserved across South African major metropolitan citis and surrounding

Service Contour Levels

The ICASA defines service contour values as the minimum usable field strength values used when calculating TV coverage using related technical parameters [11]. These values, as specified by ICASA, are provided in Table 2.

Table 2: South African Broadcasting Service Contour Values

Frequency Band	**Frequency Range**	**Field Strength**
MF Audio broadcasting	530 – 1606.5 kHz	74 dBµV/m
FM Monophonic (audio broadcasting)	87.5 – 108 MHz	60 dBµV/m
FM Stereophonic (audio broadcasting)		66 dBµV/m
VHF Analogue TV (Band III)	174 – 238 MHz 246 – 256 MHz	55dBµV/m
UHF Analogue TV (Band IV)	470 – 854 MHz	65 dBµV/m
UHF Analogue TV (Band V)		70 dBµV/m

Provincial Allocation of TV channels

For efficient use of TV spectrum, provincial allocation of TV channels for DTT might be considered by ICASA. Each province may be allocated about seven channels for DTT on the UHF band. These channels will exclude the MDTT as discussed in the previous subsection. Through this approach, channels which are allocated in one province will not be used again in the other provinces. For instance, if channels 36-42 are allocated for Western Cape, these channels can be accessed as TVWS in Limpopo Province.

D. Use of TV Spectrum for Non-Broadcasting Services

However, ICASA reserved the regulation and distribution of the digital dividend spectrum for non-broadcasting services post the DSO deadline (which is June 2015). One can only speculate that ICASA might adopt the US and EU regulation approach for the use of TVWS spectrum for providing broadband services, especially in the rural areas. This includes licence-exempt use of TVWS using either cognitive radio or the GLDB for incumbent protection.

IV. Licence-Exempt Use of TVWS For Broadband Access

There are concerns by some cellular operators that if TVWS networks are to operate in a licence-exempt manner for the provision of cellular-like services, then it is unfair and will confuse the market. So the aim of this section is to analyse the position of GSMA versus the ITU-World Radiocommunication Conference (WRC-2012) Resolution 232 for the frequency band 694-790 MHz.

A. Licence-Exempt TVWS Access for Broadband Services: Cellular Operators' Perspective

The availability and authorization to use TVWS for non-broadcast services (such as cellular services) can be viewed from two positions. Firstly, the ITU WRC-2012 resolved that the frequency band 694-790 MHz (known as the 700 MHz band or digital dividend 2 or DD2) in Region 1 (which includes Africa, Europe and Middle East) be allocated to the mobile, except aeronautical mobile, services on a co-primary basis [17]. Secondly, some countries or regulators may decide to allow mobile or cellular services to access the TVWS below the 700 MHz band post the DSO. Such access might be based on secondary access using the CR system which may include the GLDB capabilities [7].

Although the technical and regulatory conditions around the 700 MHz band for mobile services will only be specified during the WRC-2015, it is understood that its usage will not be licence-exempted. While mobile operators are happy to use this part of digital dividend to enhance their network coverage, there are concerns that licence-exempt operations of the TVWS below the 700 MHz band for wireless broadband service provision will be unfair to the mobile operators [18]. According to the GSMA's Government and Regulatory Affairs 2013 policy position paper on TVWS, the following are the mobile operators' concerns [18]:

- The licensing approach for the TVWS access should not jeopardise the future of UHF band.
- TVWS utilization should not distort the market through inappropriate regulation, thus, allowing licence-exempt operators to provide cellular-type mobiles services can create unfair advantage.

- TVWS utilization on licence-exempt secondary basis must ensure maximum protection to TV incumbent against any form of interference.

Despite the above concerns, some cellular operators see potential benefits to their networks offered by the TVWS spectrum. For instance, Fitch *et al.* [7] noted that TVWS deployments are expected to initially provide fixed rural broadband access and backhaul to small cellular cells, and then progress to provide mobile and quality of service (QoS)-aware systems. Thus, cellular operators can use TVWS to close the digital divide that exists between urban and rural areas. In turn, this will ease the pressure that cellular operators are finding themselves in from the governments, which obliges them to provide universal broadband services to the rural areas [7].

B. Typical TVWS Network Model

IEEE based standards supporting licence-exempt use of CR technology on TVWS spectrum already exists or in advanced stages of their development: IEEE 802.22 [19] and 802.11af [20]. The 802.22 is a wireless regional area network (WRAN) and uses cellular-like topology, that is, a base station (BS) provide coverage to more customer premises equipment (CPE). On the other hand, the 802.11af is similar to Wi-Fi, except that it operates on TVWS instead of the ISM bands (2.4 GHz and 5 GHz). The TVWS networks are expected to use cognitive capabilities (GLDB and CR) for TV incumbent (primary user) protection.

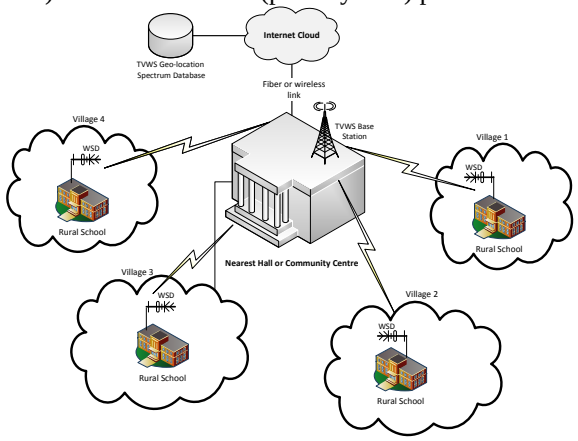

Figure 3: Typical TVWS Network for Rural Wireless Broadband Access

Figure 3 depicts a typical TVWS network deployment for rural broadband. This setup has been used during our TVWS trials in the Cape Town, where CPEs are only installed at the local schools within the 10 km radius; although this radius can be extend up to 100 km [19]. Similar setup is also planned for the proposed TVWS services trials in Limpopo Province, South Africa.

V. CONCLUSION

Like other countries, South Africa had challenges in starting the TV DSO process. While delays in political decisions may somehow be blamed for the several postponements of the switch-on or dual illumination dates, DSO complexities also played a role. The next big task for the DoC and ICASA is to establish policies and regulation around the use of TVWS for non-broadcasting services, such as Internet provision in the rural areas. We are currently involved in running the TVWS trials and conducting TV spectrum measurements around the country with the aim of promoting the use of TVWS for wireless broadband services. Our future work also includes the development of dynamic spectrum access regulations suitable for the southern African community.

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