NATIONAL COMMUNICATIONS AUTHORITY

INVITATION FOR COMMENT

1. The NATIONAL COMMUNICATIONS AUTHORITY (NCA) intends to introduce Television White Space (TVWS) Spectrum Usage Regulatory Framework in order to streamline the provision of data services in the Television Ultra-High Frequency (UHF) Bands.


4. The public consultation begins on June 27, 2016 and shall expire on 5 August, 2016.

5. All responses/comments should be electronically transmitted as e-mail attachments, in Microsoft Word format to tvwsvconsultation@nca.org.gh

6. All respondents are requested to complete a response cover sheet (see Page 3 below). The cover sheet can be downloaded on the Authority’s website, www.nca.org.gh.

7. It would be helpful if your response could include comments on the sections of the document you agree/disagree with.

Confidentiality

8. In furtherance of transparency and openness, the Authority shall consider all responses as non-confidential; accordingly all submissions shall be published on our website, www.nca.org.gh, on receipt.

9. Please note that copyright and all other intellectual property in responses shall be assumed to be licensed to NCA to use, to meet its legal requirements.

Next Step

10. Subsequent to the completion of the Public Consultation, the Authority shall proceed to publish the final Regulatory Framework for Television White Space (TVWS) Spectrum Usage in Ghana.
BASIC DETAILS
Name of respondent:

Representing (self or organisation/s):

Address:

DECLARATION
I confirm that the correspondence supplied with this cover sheet is a formal consultation response. It can be published in full on NCA’s website, and I authorise NCA to make use of the information in this response to meet its legal requirements. If I have sent my response by email, NCA can disregard any standard e-mail text about not disclosing email contents and attachments.

Name: Signed (if hard copy)
# Table of Contents

**INVITATION FOR COMMENT** ..................................................... 2

**CHAPTER 1** ............................................................................. 6
1.1 Spectrum Management Role of the Authority ................................................................. 6
1.2 What is TV White Space? ............................................................................................ 6
1.3 Main drivers for the use of TV White Spaces for data connectivity ............................ 6

**CHAPTER 2** ............................................................................. 8
2.1 Terrestrial Television Broadcasting In Ghana .............................................................. 8
   2.1.1 Analogue Terrestrial Television Authorisation Holders ........................................ 8
   2.1.2 Digital Terrestrial Television Authorisation Holders ........................................... 10
2.2 The UHF TV Bands in Accra ...................................................................................... 11

**CHAPTER 3** ............................................................................. 13
3.1 TVWS Trials in Ghana ............................................................................................... 13
   3.1.1 Spectra Wireless Trials ....................................................................................... 13
   3.1.2 Kofi Annan Advanced ICT Training Institute (AITI) Trials ............................... 15
3.2 Protection of Television Services from TVWS Users in the UHF Bands ................. 15
   3.2.1 Spectrum Occupancy Protection ...................................................................... 15
   3.2.2 Spectrum Allocation Protection ....................................................................... 15

**ANNEX1** .................................................................................. 17

Draft Regulatory Framework ......................................................................................... 17
List of Figures

Figure 1: Phase Deployment of DTT Free-to-Air Services ................................................................. 8
Figure 2: Distribution of analogue TV transmitter locations in Ghana ..................................................... 10
Figure 3: Analogue and Digital terrestrial TV Occupancy in Accra .......................................................... 12
Figure 4: Digital only terrestrial TV Channel Occupancy in Accra after analogue switch-off ...................... 12
Figure 5: Spectra Wireless TVWS Network Topology for Koforidua .......................................................... 14

List of Tables

Table 1: Analogue Terrestrial Television Stations in Ghana as at February 2016 ........................................... 9
Table 2: Digital Terrestrial Pay Television Service and Network Authorisations as at February 2016 ...... 11
CHAPTER 1

1.1 Spectrum Management Role of the Authority

The National Communications Authority is mandated by Section 58 of the Electronic Communications Act, 2008, Act 775 to “control, plan, administer, manage and license the radio frequency spectrum for telecommunication”, and to “allocate the uses of the spectrum of the electronic communications sector in a manner that promotes the economic and orderly utilisation of frequencies by electronic communications networks and services”. The Act also mandates the Authority to, “in co-operation and consultation with the users of the spectrum in the electronic communications sector in the country, develop and adopt a spectrum plan for the allocation of the uses of the spectrum”.

The National telecom Policy, 2005, states in Section 4.4 that “as technology and the market change, and new frequency bands may become available for use, NCA shall periodically review the allocation of the spectrum in Ghana, and may reallocate frequencies consistent with international standards and the interests of Ghana’s telecommunications industry and consumers”.

Ghana’s telecommunications and broadcasting sectors have gone through many phases of growth and diversification over the last decade. These changes are as a result of advancements and improvements in the usability and efficiency of technology. As these changes happen, there needs to be a corresponding review of legislation, policies and procedures, and reallocation of frequencies.

1.2 What is TV White Space?

According to the ITU report “Digital Dividend: Insights for spectrum decisions”, TV white spaces (TVWS) are “portions of spectrum left unused by broadcasting, also referred to as interleaved spectrum”. Widely, TVWS are also referred to as those currently unoccupied portions of spectrum in the terrestrial television frequency bands in the VHF and UHF TV spectrum (be it analogue or digital, generally in the UHF band).

These TV spectrum “gaps”, with advantageous propagation properties inherent to UHF spectrum (excellent outdoor and indoor coverage and non-line-of-sight propagation properties) have been identified worldwide as an alternative for providing commercial wireless services other than broadcasting. Some of the wireless technologies being explored in TVWS are low-power, machine-to-machine (M2M) communication devices and low-power wireless broadband applications, capitalizing on the longer coverage ranges achievable with UHF spectrum.

1.3 Main drivers for the use of TV White Spaces for data connectivity

“According to a recent World Bank econometrics analysis of 120 countries, for every 10-percentage-point increase in the penetration of broadband services, there is an increase in economic growth of 1.3 percentage points. This growth effect of broadband is significant and stronger in developing countries than in developed economies, and it is higher than that of telephony and Internet.”
The economic growth potential of broadband deployment necessitates the adoption of strategies to make broadband services widely available, accessible and affordable. This would have an impact on education, health and standard of living. It is the Government’s objective that every citizen and resident of the Republic of Ghana shall have access to high quality and affordable Broadband services, to facilitate the accelerated transformation of Ghana into a knowledge-based society and technology-driven economy.

Ghana has a low deployment of fixed broadband infrastructure (such as fibre, ADSL, etc), hence there is a high reliance on wireless infrastructure for the provision of broadband connectivity. Wireless broadband communication provides a more affordable and flexible alternative for providing internet access to citizens and contributes in a more expedite way in reducing the digital divide. The increase in demand for mobile wireless access and the consequent growth of mobile networks could also be a contributing factor to an increase in demand for ancillary wireless platforms in other frequency bands, intended to support the operation of mobile networks, such as microwave links used for backhaul.

With the steep increase in the demand for mobile connectivity in Ghana, comes the inevitable pressure on the supply side of the resource, being the radio spectrum to enable wireless technologies to transmit and receive data. Noting that, while levels of spectrum demand are likely to vary across different regions depending on factors such as population density and scale of development of broadband fixed networks, the rise of advanced consumer mobile devices and data-demanding mobile applications has considerably increased the usage of bandwidth in mobile spectrum bands in both, carrier-grade level mobile networks (i.e. 3G & 4G networks) and license-exempt local area networks (i.e. Wi-Fi access).

This demand for more wireless spectrum has led to research into alternative forms of spectrum utilization in recent years. This has led to the consideration of TVWS as an option for addressing connectivity needs ranging from spectrum-congested zones in highly developed metropolitan areas (with high degrees of UHF TV spectrum idleness) to vast geographical rural areas lacking access infrastructure and needing lower-cost deployment alternatives (and with low UHF TV broadcasting usage). Considering the increasing demand for mobile spectrum, the search for alternative ways of achieving maximum spectrum efficiency becomes extremely important for policy makers, regulators and the private sector. Collaboration of all these stakeholders is necessary for achieving not only efficient use of the spectrum resource but also to ensure sustainability of the ICT ecosystem. ICT deployments will continue to face increasing demand in terms of spectrum access in congested areas, as networks expand in developing regions to bridge connectivity gaps.
CHAPTER 2

2.1 Terrestrial Television Broadcasting In Ghana

At present, Ghana is in the process of switching over analogue terrestrial television networks to digital technology. This transition generally involves three main steps:

- **Digital Switch-on**: The rollout of digital terrestrial television (DTT) services. Private Digital Terrestrial Pay TV services have been rolled out in all the major cities in Ghana. However, these services are encrypted and require subscription to be viewed. The Government has committed to roll out a DTT network to carry all authorized analogue terrestrial television services in the digital domain. This network is being rolled out in phases, as shown in Fig. 1 below. Phase one is expected to be completed by the end of March 2016.

![Figure 1: Phase Deployment of DTT Free-to-Air Services](image)

- **Double illumination / Simulcast**: The period when television services are available in both analogue and digital terrestrial formats. This is required to allow consumers of terrestrial television services to acquire the right receiving apparatus for digital TV i.e. set-top boxes to convert existing analogue TV sets or integrated digital TV sets.

- **Analogue Switch-Off (ASO)**: The switching off of analogue transmitters to complete the transition. After ASO, terrestrial television services shall be available only in digital form. ASO would be done in phases/regions. The dates for each phase shall be announced by the Ministry of Communications.

2.1.1 Analogue Terrestrial Television Authorisation Holders

There are currently twenty one (21) analogue terrestrial television Authorisation holders, out of which fifteen (15) are operational, as shown in Table 1 below.
<table>
<thead>
<tr>
<th>No.</th>
<th>Company Name</th>
<th>Trade Name</th>
<th>Date Of Authorisation</th>
<th>Frequency Band Of Operation</th>
<th>Area(s) Of Operation</th>
<th>Comment(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ghana Broadcasting Corporation</td>
<td>GTV</td>
<td>1968 BY NLCD 226,</td>
<td>VHF</td>
<td>Nationwide</td>
<td>Station On Air &amp; simulcasts in Digital. Operates 8 additional digital programme channels</td>
</tr>
<tr>
<td>2</td>
<td>TV 3 Network Limited</td>
<td>TV3</td>
<td>17 September 1996</td>
<td>VHF (has a UHF gap filler in</td>
<td>10 regional capitals</td>
<td>Station On Air &amp; simulcasts in Digital</td>
</tr>
<tr>
<td>3</td>
<td>Metropolitan Entertainment Television</td>
<td>Metro TV</td>
<td>5 September 1997</td>
<td>VHF</td>
<td>10 regional capitals</td>
<td>Station On Air &amp; simulcasts in Digital</td>
</tr>
<tr>
<td>4</td>
<td>Television Africa Limited.</td>
<td>TV Africa</td>
<td>21 November 1995</td>
<td>VHF</td>
<td>Greater Accra Region</td>
<td>Station On Air &amp; Guaranteed Operation of Digital Terrestrial Programme Channel</td>
</tr>
<tr>
<td>5</td>
<td>Crystal Radiovision Network Limited</td>
<td>Crystal TV</td>
<td>1995</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station On Air with three programme channels &amp; simulcasts in Digital</td>
</tr>
<tr>
<td>6</td>
<td>Net 2 TV Limited</td>
<td>Net 2 TV</td>
<td>7 April 2004</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station On Air &amp; Guaranteed Operation of Digital Terrestrial Programme Channel</td>
</tr>
<tr>
<td>7</td>
<td>Independent TV Limited</td>
<td>Top TV</td>
<td>1 April 2008</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station On Air &amp; simulcasts in Digital</td>
</tr>
<tr>
<td>8</td>
<td>K &amp; N Investment</td>
<td>E-TV Ghana</td>
<td>19 October 2006</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station On Air &amp; simulcasts in Digital</td>
</tr>
<tr>
<td>9</td>
<td>Viasat Broadcasting Limited</td>
<td>Viasat 1</td>
<td>22 February 2008</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station On Air &amp; simulcasts in Digital</td>
</tr>
<tr>
<td>10</td>
<td>Three Angles Broadcasting Network Ghana</td>
<td>3ABN</td>
<td>11 August 2008</td>
<td>UHF</td>
<td>Not on Air</td>
<td>Station Not on Air but Guaranteed Operation of Digital Terrestrial Programme Channel</td>
</tr>
<tr>
<td>11</td>
<td>Multiple Concepts</td>
<td>GH One</td>
<td>5 January 2009</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station on Air &amp; Guaranteed Operation of Digital Terrestrial Programme Channel</td>
</tr>
<tr>
<td>12</td>
<td>Smart Multimedia</td>
<td>Light TV</td>
<td>23 December 2008</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station on Air &amp; Guaranteed Operation of Digital Terrestrial Programme Channel</td>
</tr>
<tr>
<td>13</td>
<td>U2 Company Limited</td>
<td>UTV</td>
<td>20 January 2009</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station On Air &amp; simulcasts in Digital</td>
</tr>
<tr>
<td>14</td>
<td>Integrated Media Xchange (IMX)</td>
<td>-</td>
<td>7 January 2009</td>
<td>UHF</td>
<td>Not on Air</td>
<td>Station not on Air but Guaranteed Operation of Digital Terrestrial Programme Channel</td>
</tr>
<tr>
<td>15</td>
<td>The Cardinal Foundation For Distance Learning</td>
<td>Cafdir</td>
<td>11 February 2005</td>
<td>UHF</td>
<td>Central Region</td>
<td>Station on Air &amp; Guaranteed Operation of Digital Terrestrial Programme</td>
</tr>
<tr>
<td>No.</td>
<td>Company Name</td>
<td>Trade Name</td>
<td>Date Of Authorisation</td>
<td>Frequency Band Of Operation</td>
<td>Area(s) Of Operation</td>
<td>Comment(S)</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>----------------------</td>
<td>-----------------------------</td>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>16</td>
<td>Centre For Intercultural Learning Talent &amp;</td>
<td>Coastal TV</td>
<td>16 October 2007</td>
<td>UHF</td>
<td>Central Region</td>
<td>Station on Air &amp; Guaranteed Operation of Digital Terrestrial Programme</td>
</tr>
<tr>
<td></td>
<td>Development, Agoro</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Channel</td>
</tr>
<tr>
<td>17</td>
<td>Great Kosa Company Limited</td>
<td>Kantanka TV</td>
<td>27 August 2008</td>
<td>UHF</td>
<td>Greater Accra Region</td>
<td>Station on Air &amp; Guaranteed Operation of Digital Terrestrial Programme</td>
</tr>
<tr>
<td>18</td>
<td>Empire Broadcasting Network</td>
<td></td>
<td>9 May 2008</td>
<td>UHF</td>
<td>Not on Air</td>
<td>Station not on Air but Guaranteed Operation of Digital Terrestrial Programme</td>
</tr>
<tr>
<td>19</td>
<td>HBA TV &amp; Communications Network</td>
<td></td>
<td>24 June 2008</td>
<td>UHF</td>
<td>Not on Air</td>
<td>Station not on Air but Guaranteed Operation of Digital Terrestrial Programme</td>
</tr>
<tr>
<td>20</td>
<td>C Television Limited</td>
<td>CTV</td>
<td>3 October, 2008</td>
<td>UHF</td>
<td>Not on Air</td>
<td>Station not on Air but Guaranteed Operation of Digital Terrestrial Programme</td>
</tr>
<tr>
<td>21</td>
<td>Orakle Advertising Limited</td>
<td></td>
<td>10 November, 2008</td>
<td>UHF</td>
<td>Not on Air</td>
<td>Station not on Air but Guaranteed Operation of Digital Terrestrial Programme</td>
</tr>
</tbody>
</table>

The Map below (Fig. 2) shows analogue transmitter distribution in Ghana. This map shows that most of these transmitters are crowded in the South and Middle zones, and sparse in the Northern zones. Most television channels broadcast exclusively in the Southern belt.

![Figure 2: Distribution of analogue TV transmitter locations in Ghana](image)

2.1.2 Digital Terrestrial Television Authorisation Holders
There are currently four (4) digital terrestrial Pay terrestrial television service and network Authorisation holders, out of which three (3) are operational, and one is running trials, as shown in Table 2.
Table 2: Digital Terrestrial Pay Television Service and Network Authorisations as at February 2016

<table>
<thead>
<tr>
<th>No.</th>
<th>COMPANY NAME</th>
<th>TRADE NAME</th>
<th>DATE OF FIRST AUTHORISATION</th>
<th>FREQUENCY BAND</th>
<th>REGION OF OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CATV LIMITED</td>
<td>CABLE GOLD</td>
<td>29-01-1997</td>
<td>UHF (2 Multiplexes)</td>
<td>Greater Accra</td>
</tr>
<tr>
<td>2</td>
<td>CRYSTAL RADIOVISION NETWORK LIMITED</td>
<td>CRYSTAL TV</td>
<td>12-03-2002</td>
<td>UHF (2 Multiplexes)</td>
<td>Greater Accra</td>
</tr>
<tr>
<td>3</td>
<td>WILSAD SUPPORT LIMITED</td>
<td>FIRST DIGITAL</td>
<td>13-12-2004</td>
<td>UHF (2 Multiplexes)</td>
<td>Greater Accra Eastern Central Ashanti Western</td>
</tr>
<tr>
<td>4</td>
<td>GOtv GHANA LIMITED</td>
<td>GOtv</td>
<td>14/4/2000</td>
<td>UHF (2 Multiplexes)</td>
<td>Greater Accra Eastern Western Central Ashanti Northern Brong Ahafo</td>
</tr>
</tbody>
</table>

**2.2 The UHF TV Bands in Accra**

At present, Ghana is in the process of switching over analogue terrestrial television networks to digital technology, and it is expected that this switchover will free up large blocks of spectrum. This is because digital technology (in the case of Ghana DVB-T2) will allow about twenty (20) programme channels to be multiplexed (packed into) the same frequency channel that is used by one programme channel in analogue technology. Also, digital transmissions can be packed into adjacent frequency channels, while analogue channels cannot. This means that the band can be "compressed" into fewer channels, while still allowing for more transmissions.

Fig. 3 and Fig. 4 are occupancy plots of the Ultra-High Frequency (UHF) television Bands IV and V. The red lines represent analogue TV signals and the blue lines represent digital TV signals. Fig. 3 is the occupancy showing both analogue and digital TV signals during simulcast and Fig. 4 is the band after analogue switch-off.

In Fig. 3, the UHF bands seem almost crowded during the co-existence/simulcast of analogue and digital TV signals, but after analogue switch-off, the band will look half-empty, as shown in Fig 4.
Figure 3: Analogue and Digital terrestrial TV Occupancy in Accra

Figure 4: Digital only terrestrial TV Channel Occupancy in Accra after analogue switch-off
CHAPTER 3

3.1 TVWS Trials in Ghana

In June 2013, the National Communications Authority initiated steps to experiment with TVWS technology as another option for addressing data connectivity needs ranging from spectrum-congested zones in highly developed metropolitan areas (with high degrees of UHF TV spectrum usage) to vast geographical rural areas lacking access infrastructure and requiring lower-cost deployment alternatives (and with low UHF TV broadcasting usage).

At the time, considering the possibility of appropriate coordination achieved by a combination of database-managed channel assignment, geo-location and a compatible set of technical specifications, TVWS technology operating on a secondary basis in the TV UHF bands was not seen to necessarily represent an unmanageable hurdle in terms of licensing. There were already various international spectrum allocations that included secondary allocations, which were subject to operational coordination and interference management measures in order to allow co-existence between the services occupying the same spectrum bands. It was therefore considered that a well-defined data/internet licensing regime (on a non-interference/ non-protection basis) for TVWS could well serve as a viable option for co-existence of TVWS with the incumbent TV Broadcasting service, provided that the nature of the primary service remains the same and technically compatible to allow its operation free of harmful interference.

That year, the Authority engaged Google Inc. of the USA to access the terrestrial television channel allocations and its suitability for television white space implementation in Ghana. This engagement was necessitated by the then on-going TVWS trials in the United States of America, the United Kingdom and Singapore, and Google’s active participation in all these trials. The Authority consequently constituted a TVWS Project Implementation Team to:

- study the emerging technology,
- supervise TVWS trials in Ghana, and
- make recommendations for implementation.

3.1.1 Spectra Wireless Trials

The Authority authorised Spectra Wireless to run a 6-month trial on January 08, 2014. This Authorisation required Spectra Wireless to carry out trials and provide monthly reports of its findings during these trials. These reports were intended to assist the Authority to observe the coexistence of TVWS devices with broadcast services and also aid the formulation of regulations for TVWS services in the country.

3.1.1.1 Labadi Beach Hotel Trials

Spectra Wireless conducted its first trials at the Labadi Beach Hotel, Accra to provide high-speed internet during the Dynamic Spectrum Alliance Global Summit held from 22-24 February, 2014. This trail was used to observe how TVWS devices interact and coexist with primary users of the band i.e TV broadcast services. The network comprised of a TVWS backhaul link from the MainOne Cable Landing Site at Teshie-Nungua to the hotel, and cable connections to WIFI Access Points (WIFI APs) for the provision of high-speed internet access.
During this trial, there was no geo-location database, and so Spectra Wireless performed a spectrum occupancy scan and assigned unused channels to their radios (a technique known as spectrum sensing) during installation. Several co-existence and interference scenarios were tested during the trials, and the results came out successful.

3.1.1.2 Meltwater Entrepreneurial School of Technology (MEST) Trials

After the success of the Labadi Beach Hotel Trials, Spectral Wireless conducted its second trials at the Meltwater Entrepreneurial School of Technology (MEST), East Legon. The network comprised a TVWS backhaul link from the MainOne Cable Landing Site (CLS) at Teshie-Nungua to the MEST campus and a WiFi access link at MEST for internet and data connectivity. Spectrum sensing was also used in this trial due to the absence of a geo-location database.

This second trial was also successful, and internet speeds of 5mbps were achieved.

3.1.1.3 Koforidua Commercial Pilot

After a successful non-commercial trial, Spectra Wireless was authorised to begin a commercial trial on December 08, 2014. Spectra Wireless deployed its commercial pilot network at the Koforidua Polytechnic Campus. The network layout is outlined in Figure 5 below. The Network Operating Centre (NOC) located at East Legon, Accra is connected to the MainOne landing site at Nungua (CLS) using a TVWS link. The main base station at the CCB building at Koforidua Polytechnic is connected to a fibre-leased-circuit from Vodafone at the Oboutabiri Mountain through a 5.4GHz microwave link. From this base station, there are TVWS links to the Main Administration Block, the Faculty of Engineering Building, GetFund Hostel on campus, three private hostels (Plantain Hostel, Universal Hostel and Vine Hostel) located close to the campus and the Koforidua Secondary Technical School. At each of these locations, WIFI Aps are used to provide high-speed internet access. Spectrum sensing was used in this trial due to the absence of a geo-location database.

![Spectra Wireless TVWS Topology for Koforidua](image)

**Figure 5: Spectra Wireless TVWS Network Topology for Koforidua**
3.1.1.4 Koforidua Secondary Technical School (Koforidua SecTec) Pilot

Spectra Wireless Limited, as part of its corporate social responsibility and in furtherance of their strategy to provide internet connectivity for underserved and underprivileged communities, has created a TVWS link from its main base station in Koforidua Polytechnic to the Koforidua Secondary Technical School to deliver free internet access to the school.

3.1.2 Kofi Annan Advanced ICT Training Institute (AITI) Trials

Advanced Information Technology Institute (AITI) was authorized to establish and operate a Television White Space (TVWS) pilot project on July 7, 2014. The network comprised a TVWS base station located at the AITI premises at Ridge, and client installations located at the Ringway Estates Junior High School, Osu Manhean Cluster of Schools and Osu Cluster of Schools, all at Osu, Accra. The measurements were conducted at the Ringway Estates JHS installation, and Spectrum sensing was also used to assign the channels.

This trial was successful. Downlink speeds of 7Mbps and uplink speeds of 2Mbps were observed during an inspection conducted by the NCA.

3.2 Protection of Television Services from TVWS Users in the UHF Bands

Protecting licensed broadcast television viewers from harmful interference due to secondary spectrum usage is critical to the successful deployment of TV white space devices.

3.2.1 Spectrum Occupancy Protection

During the Spectra wireless trials, the emission from the TVWS devices occupied 6MHz out of the 8MHz UHF TV channel, thus leaving a guard band of 1MHz at each edge. The AITI TVWS devices occupied 7MHz out of the 8MHz channel, leaving a guard band of 0.5MHz at each edge.

3.2.2 Spectrum Allocation Protection

Numerous methods exist for protecting incumbent systems, principal among which are spectrum sensing-only methods and geo-location database techniques. The reliability of these methods is of paramount concern to the successful deployment of TVWS.

The two main spectrum allocation methods are:

- **Spectrum sensing**: the ability to measure, sense and be aware of the parameters related to the radio channel characteristics, availability of spectrum and transmit power, interference and noise, radio’s operating environment, user requirements and applications, available networks (infrastructures) and nodes, local policies and other operating restrictions.
Geo-location database techniques: reliance on known information about the bands, including the exact types of incumbent services present and their specific protection requirements. Geo-location databases protect TV band incumbents by keeping track of TV transmitters and their protected service areas based on their location, transmission parameters and sophisticated propagation models.

During the trials, in the absence of a geolocation database, spectrum sensing was used to allocate the TVWS channels for use. However, the Authority will mandate the use of the geo-location database allocation during full-scale TVWS deployments.
Draft Regulatory Framework

1. PURPOSE

This National Communications Authority framework will allow data radio transmitters to operate in the UHF band, which is allocated on a primary basis to broadcast television services, on frequencies and at locations where that spectrum is not assigned to licensed services, while protecting licensed television broadcasting users operating in these frequencies from receiving harmful interference.

2. DEFINITIONS AND ABBREVIATIONS

“Adjacent Channel Leakage Ratio (ACLR)” – The ratio of the in-band transmit power measured in an eight-megahertz (8 MHz) TV channel, to the out-of-band emission measured in 100 kHz in an adjacent TV channel.

“Altitude” – The height above the reference level defined by WGS84.

“Authentication” – The ability to verify that a message was truly sent by the asserted sender.

“Available channel” - A 8 MHz television channel in the UHF TV Band which is not being used by a licensed service at or near the same geographic location as the TVWS device and is acceptable for use by a device under the provisions of these technical rules.

“Client device” – See “Mode I Personal / Portable Device”

“Contact verification signal” – An encoded signal broadcast by a fixed or Mode II device for reception by Mode I devices to which the fixed of Mode II devices has provided a list of available channels for operation. A fixed or Mode II device shall provide the information needed by a Mode I device to decode the contact verification signal at the same time it provides the list of available channels.

“Device emission class” – The classification declared by the manufacturer that identifies the level of ACLR for the device

“ETSI” – European Technical Standards Institute

“ETSI EN 301 598” – The ETSI Harmonized European Standard for “White Space Devices (WSD); Wireless Access Systems operating in the 470 MHz to 790 MHz TV broadcast band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive”, final draft V1.0.9 (2014-02).

“Fixed device” – A TVWS device that transmits and/or receives communications at a specified fixed location and obtains information on available channels from a geo-location database. A fixed TVWS device is required to have an internal geo-location capability. A fixed TVWS device may initiate and operate a network by sending enabling signals to one or more fixed TVWS devices and/or personal/portable TVWS devices.

“Geo-location capability” – The capability of a TVWS device to determine and report the latitude, longitude and altitude coordinates of its antenna.
“Geo-location uncertainty” – The positioning error in all three dimensions defined by the difference in meters between the point reported by the TVWS device to the database and the actual position of the TVWS antenna.

“Integral antenna” – The antenna designed as a fixed part of the equipment, without the use of an external connector, which cannot be disconnected from the equipment by a user with the intent to connect another antenna. An integral antenna may be fitted internally or externally. In the case where the antenna is external, a non-detachable cable can be used.

“Master device” – is a fixed or Mode II personal/portable device that uses a geo-location capability and access to a geolocation database, either through a direct connection to the Internet or through an indirect connection to the Internet by connecting to another master device, to obtain a list of available frequencies.

“Mobile TVWS device” – A TVWS device that transmits and receives communications while moving or from different unspecified fixed points that may change.

“Mode I device” – A personal / portable device does not have an internal geolocation capability and does not directly access a TVWS database to obtain a list of available white space channels. Rather it obtains this information from a fixed or Mode II device. A Mode I device shall not initiate a network of white space devices nor provide a list of available white space channels to another Mode I device.

“Mode II device” – A personal / portable device that uses an internal geo-location capability to access a TVWS database either directly or through another mode II device.

“Network initiation” – The process by which a fixed or Mode II device sends control signals to one or more fixed or personal / portable devices and allows them to begin communications.

“Operating channel” – An available channel used by a TVWS device for transmission and/or reception.

“Out-of-block-emissions” – Unwanted emissions that fall within the 470 MHz to 790 MHz band.

“Personal / portable device” – A mobile TVWS device with an integral antenna that can be carried by the user.

“Primary basis” – The primary service, which is the main service allocated to a specific band in the national frequency allocation table for a particular region or country, has priority over all other users of the spectrum band.

“Sleep Mode” – is a mode in which the device is inactive but is not powered-down.

“Time validity” – The period of time when a set of operational parameters provided by the geo-location database to a fixed or Mode II device is in force.

“TV” – Television.

“TV White Spaces (TVWS)” – Frequencies within the 470 MHz to 790 MHz band which have been identified by a TVWS database for use by a TVWS device.

“TVWS database” – A database system approved by NCA that maintains records of all authorized services in the UHF band, can communicate with fixed and Mode II devices, and is capable of determining the available channels and power levels for such devices at a specific geographic location.
“TVWS device” - Radio equipment that operates in the TV white spaces of the UHF TV band.

“Ultra-High Frequency (UHF) TV band” means the frequency band from 470 – 790 MHz

“White spaces” - refer to geographical areas where the radio spectrum is not used by the license

3. PERMITTED CHANNELS OF OPERATION

3.1 TVWS devices are allowed to operate in the UHF Band IV (470-528 MHz) and Band V (528-694 MHz) that are allocated on a primary basis to broadcast television services, subject to the interference protection requirements set forth in these technical rules and regulations.

3.2 TVWS devices shall operate on available frequencies determined in accordance with the interference avoidance mechanisms in Section 9.

3.3 TVWS devices shall not operate on a co-channel basis with broadcast television stations in the same region if the TVWS database indicates that the channel is not available for use in that region.

3.4 Client TVWS devices shall only operate on available frequencies determined by Master TVWS device.

4. LICENSING FRAMEWORK FOR TVWS SERVICES

4.1 TVWS Services will be treated as an Internet/Public Data Service with its attendant regulatory fees. The spectrum charge will be the same as for an ISM (Industrial, Scientific and Medical) assignment.

5. RADIATED POWER LIMITS

5.1 A TVWS device depending on the geo-location and database method of determining channel availability may be required to operate at lower power than the maximum permitted in order to meet the co-channel and adjacent channel separation requirements.

5.2 Fixed devices – Up to 4 W (36 dBm) EIRP within the six metropolitan districts and up to 10 W (40 dBm) ERP elsewhere, contingent on meeting the co-channel and adjacent channel separation distances required to protect licensed broadcast TV operations and other licensed users at that location.

5.3 Personal / portable devices – Up to 100 mW (20 dBm) EIRP, contingent on meeting the co-channel and adjacent channel separation distances required to protect licensed broadcast TV operations and other licensed users at that location.

6. CONDUCTED POWER LIMITS

6.1 Transmitted Power Control – A TVWS device shall incorporate transmit power control to limit its operating power to the minimum necessary for a successful communication to be completed.
6.2 Fixed Device – The maximum conducted power is 1 W (30 dBm) EIRP and the conducted power spectral density limit at the maximum conducted power level is 17.0 dBm EIRP as measured within any 100 kHz frequency block within the channel.

6.3 Personal / Portable Device – The maximum conducted power is 100 mW EIRP and the conducted power spectral density limit at the maximum conducted power level is 1.0 dBm EIRP as measured within any 100 kHz frequency block within the channel.

7. OUT OF BLOCK EMISSIONS LIMITS

7.1 TVWS Operating Channel Immediately Adjacent to a Protected Broadcast TV Channel

7.1.1 In the television channels immediately adjacent to the channel in which the TVWS device is operating, out-of-block-emissions from TVWS devices relying on the geo-location and database techniques of determining channel availability shall be based on the ACLR established for the TVWS device emission classes described in Section 4.2.4.2 of ETSI EN 301 598.

7.1.2 ACLR for TVWS Operations on the First Adjacent Channel

<table>
<thead>
<tr>
<th>Device Emission Class</th>
<th>ACLR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>74</td>
</tr>
<tr>
<td>Class 2</td>
<td>74</td>
</tr>
<tr>
<td>Class 3</td>
<td>64</td>
</tr>
<tr>
<td>Class 4</td>
<td>54</td>
</tr>
<tr>
<td>Class 5</td>
<td>43</td>
</tr>
</tbody>
</table>

7.1.3 Out of block (OOB) EIRP spectral density limit – As measured in the first 100 kHz beyond the channel edge, the OOB is the greater of the measured in-block conducted power spectral density over 8 MHz (PIB) minus the ACLR or -84 dBm. The equation is:

\[ \text{POOB (dBm} / (100 \text{kHz})) < \max \{ \text{PIB (dBm} / (8 \text{MHz})) - \text{ACLR (dB)}, -84 \text{ (dBm} / (100 \text{kHz})) \} , \]

7.2 TVWS Operating Channel Not Immediately Adjacent to a Protected Broadcast TV Channel

7.2.1 At frequencies beyond 8 MHz from the protected broadcast TV Channel, TVWS device’s field strength must be no greater than 200 microvolts per meter as measured from a distance of 3 meters away.

7.3 TVWS Operations Near International Borders

7.3.1. TVWS devices will have to operate in a manner that will not cause harmful interference to broadcasting and other services in the neighboring countries. All signals propagated from a TVWS device reaching the Ghana borders will be at the noise floor level of -115 dBm.
8. ANTENNA REQUIREMENTS AND LIMITS

8.1 Fixed Devices

8.1.1 Fixed devices may be professionally installed

8.1.2 The TVWS device shall automatically store its antenna height at the time of installation, first power on, and at any time after it is relocated.

8.1.3 The transmit antenna height shall not exceed 30 meters above ground level and shall not be located where the height above average terrain, as calculated by the TVWS database, is greater than 250 meters.

8.1.4 The maximum radiated power of 4 W (36 dB) EIRP in the six metropolitan districts can be achieved using any combination of conducted power levels up to 1 W (30 dB) EIRP and antenna with the corresponding gain, after compensation for cable and other loss mechanisms.

8.1.5 The maximum radiated power of 10 W ERP in rural areas can be achieved using 1 W EIRP conducted power combined with a 10 dBi gain antenna, after compensating for cable and other loss mechanisms.

8.2 Personal / Portable Devices

8.2.1 The transmit antenna of a personal / portable device shall have permanently attached or integral transmit and receive antenna(s).

8.2.2 The antenna height of a personal / portable device shall be taken by the white spaces database as 1.5 meters above ground level, unless the TVWS device notifies the databases otherwise.

8.2.3 If the personal / portable device does report its height information, and that height is more than 2.0 meters above ground, the device is presumed to be operating in-doors, and an additional 7 dB of power may be permitted to compensate for building loss.

9 INTERFERENCE AVOIDANCE

9.1 GEO-LOCATION REQUIRED

9.1.1 TVWS devices shall rely on a geo-location capability and database access mechanisms to protect television broadcasters and other authorized services operating in UHF Bands IV and V.

9.2 GEO-LOCATION REQUIREMENTS OF FIXED DEVICES

9.2.1 Each fixed device must be registered with a TVWS database provider at the time of installation and prior to first activation.

9.2.2 The geographic coordinates of a fixed device shall be determined to an accuracy of ± 50 meters by means of an automated internal geolocation capability. The geographic coordinates and antenna height above ground level of a fixed device shall be determined at the time of installation and first activation from a power-off condition, and this information shall be stored by the device.
9.2.2 If the fixed device is moved to another location or if its stored coordinates become altered, the operator shall re-establish the device’s geographic location by means of an automated internal geolocation capability.

9.2.3. A fixed device will query an authorized geo-location TVWS database over the Internet with its operating location (coordinates in longitude and latitude), altitude of its transmitting antenna, device emission class, and geo-location uncertainty prior to its initial service transmission at a given location. In addition to the above information, the device must provide:

a) The unique TVWS device Identifier

b) The name of the individual or business that is responsible for the TVWS device

c) Name, address, email and phone number of the contact person responsible for the TVWS device’s operation

9.2.4 Operation is permitted only on channels and at power levels that are indicated in the database as being available for fixed devices. Operation on a channel must cease immediately or the power must be reduced to a permissible level if the database indicates that the channel is no longer available at the current operating level.

9.3 GEO-LOCATION REQUIREMENT FOR MODE II DEVICES

9.3.1 A Mode II master device shall use automated geolocation to determine its location. The device shall report its geographic coordinates as well as the accuracy of its geolocation capability (e.g., +/- 50 meters, +/- 100 meters) to the database.

9.3.2 A Mode II master device must also re-establish its position each time it is activated from a power-off condition and use its geolocation capability to check its location at least once every 60 seconds while in operation, except while in sleep mode, i.e., a mode in which the device is inactive but not powered down.

9.3.3 A Mode II master device will query an authorized geo-location TVWS database over the Internet with its operating location (coordinates in longitude and latitude), device emission class, geo-location uncertainty prior to its initial service transmission at a given location. It may report its height information.

9.3.4 Operation is permitted only on channels and at power levels that are indicated in the database as being available for the Mode II master device. Operation on a channel must cease immediately or power must be reduced to a permissible level if the database indicates that the channel is no longer available at the current operating level.

9.4 GEO-LOCATION REQUIREMENT FOR MODE I DEVICES

9.4.1 A Mode I device may only transmit upon receiving a list of available channels from a fixed or Mode II device. A fixed or Mode I device may provide a Mode I device with a list of available channels only after it contacts its database, provides the white space database with the NCA Identifier of the Mode I
device requesting available channels, and receives verification from the white space database that the NCA Identifier is valid for operation.

9.4.2 A Mode II device must provide a list of channels to the Mode I device that is the same as the list of channels available to the Mode II personal / portable TVWS device. A Mode I device shall not operate at a conducted power level greater than that of the Mode II device that provides it the list of available channels at that location.

9.4.3 A fixed device may provide a list of available channels to a Mode I device only if the device altitude as verified by the white space database does not exceed any height restriction put in place by NCA. The fixed device must provide a list of all available channels to the Mode I device.

9.4.4 To initiate contact with a fixed Mode II device, a Mode I device may transmit on an available channel used by a fixed or Mode II device.

9.5 FREQUENCY OF DATABASE ACCESS

9.5.1. Fixed device – Each fixed device shall access the database at least once every twelve (12) hours to verify that the operating channels continue to remain available. Each fixed device must adjust its use of channels accordingly. A fixed device can only operate after it has successfully queried an authorized geo-location database and has received channel availability and maximum transmission power information from it. Alternatively, the TVWS database can provide the fixed device a time validity for the operation of the channel.

9.5.2 Mode II device

9.5.2.1 The location of a Mode II device must be checked at least once every 60 seconds while in operation, except while in sleep mode.

9.5.2.2 A Mode II device that has been in a powered state shall re-check its location and access the database every twelve (12) hours to verify that the operating channel(s) and corresponding levels continue to be available. A Mode II device must adjust its use of channels and power levels accordingly. Alternatively, the white space database can provide the Mode II device a time validity for the operation of the channel.

9.5.3 Mode I personal / portable TVWS device – Except while in sleep mode, a Mode I personal / portable device must either receive a contact verification signal from the Mode II or fixed TVWS device that provided its current list of available channels or contact a Mode II or fixed device to re-verify / re-establish channel availability at least once every 60 seconds.

9.5.4 Continuing operations

9.5.4.1 If a fixed or Mode II device fails to successfully contact the white space database during any given 12-hour period, it may continue to operate until 11:59 pm of the following day at which time it must cease operations until it re-establishes contact with the white space database and re-verifies its list of available channels.
9.5.4.2 Mode I device – A Mode I device must cease operation immediately if it does not receive a contact verification signal or is not able to re-establish a list of available channels through contact with a fixed or Mode II device within 60 seconds of last contact. The Mode I device must then re-initiate contact.

9.6 GEOLOCATION DATABASE SECURITY MECHANISMS

9.6.1. Communications security and authentication procedures shall be instituted to ensure that geo-location databases are protected from unauthorized data input or alteration of stored data.

9.6.2. Communications between the database and TVWS devices shall be secured in a manner to prevent unauthorized parties from accessing information during transit.

9.7.3 TVWS devices shall incorporate adequate security measures to prevent the devices from accessing databases not approved by NCA.

10 INFORMATION DISPLAY REQUIREMENTS

10.1 Display of available channels – A TVWS device must incorporate the capability to display a list of available channels and its operating channel

10.2 Labelling Requirements – TVWS device shall bear the following statement in conspicuous location on the device:

“This device complies with all applicable NCA Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

10.3 Instructions to User Regarding Correction of Harmful Interference

10.3.1 The text of the TVWS user manual regardless of what form it is provided in (paper, computer disk, on-line) shall include the following statement placed in a prominent location within the manual

“This equipment has been tested and found to comply with the technical rules and regulations for TVWS devices, consistent with all applicable NCA regulations. These rules have been formulated to furnish reasonable protection against harmful interference. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. If this equipment does cause harmful interference to radio or television reception, the user is encouraged to try to correct the interference by one or more of the following measures:

(1) Reorient or relocate the receiving antenna.
(2) Increase the separation between the equipment and the receiver.
(3) Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
(4) Consult the manufacturer, dealer or an experienced radio / TV technician for help.
10.4 Compliance with radio frequency exposure requirements

10.4.1 Fixed Devices – A fixed device shall be accompanied by instructions on measures to take to ensure that persons maintain a distance of at least 40 cm from the device, as well as any necessary hardware that may be needed to implement that protection. These instructions shall be displayed in all formats of the user manual.