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Assessing The Impact of Digital Terrestrial Television Switchover Deployment on Broadcasting in Nigeria: A Study of Nigerian Television Authority, Enugu.

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Abstract-* This paper presents the review of deployment of digital terrestrial switchover from the old analog transmission which has lasted for over 6 decades in the country. Though the deployment of digital terrestrial transmission requires huge capital investments in terms of equipment and human resources but it provides huge benefits as shown in this review work. The digital switch over would provide the following benefits: Provision of clear video and audio signals, optimal and efficient utilization of the allocated bandwidth, provision of web based services, interaction between television stations and viewers and so many other benefits. Digital techniques, such as the Data Encryption Standard (DES), double DES, and triple DES give operators hope that they can secure their pay-per-view content and charge subscribers to generate revenue which was not possible with analog terrestrial transmission. Signals (video and audio) are produced in a studio where the conditions can be controlled and meet the high standard of requirements for productions with the best sound and picture quality. In the course of this work, nine locations were selected in Enugu, Nigeria, to measure the Signal strengths of both analog and digital television receptions using the set top boxes. It was observed that the signal quality for analog reception degraded badly over the same distances where the digital receptions were found to be of high quality in terms of received video and audio signals strength. Hence, from the studies carried out at the ten selected different locations in Enugu, it was discovered that under the same transmitter power of 3.5KW and carrier frequency of 625MHZ, that those locations with very poor analog signal receptions recorded high digital signal receptions provided that the received signal strength outweighs the receiver sensitivity. Owing to the benefits of the digital terrestrial television, its penetration in Enugu reached 90% mark within the first three years of deployment. However, after more than ten years of deployment, instead of the digital penetration hitting the expected 98% mark, it has rather declined to about 69% with more possibilities of further declining. This decline in digital penetration was as a result of so many factors like inadequate set top boxes, unresolved network issues affecting most of the set top boxes deployed, poor funding of the scheme that makes signal availability erratic, poor and insufficient programmes by the content providers which has resulted to excessive repetition of programmes. This programme repetition bores the viewers. Hence, this review work was carried out to identify the above mentioned challenges and proffer remedial measures so as to deepen the digital television transmission and equally cover rural areas which are yet to be captured by the scheme.

Key Words: Digital switch over, Terrestrial, Video, Sound, Transmitter and Television.

I. INTRODUCTION

The movement towards widespread digital television (DTV) gained momentum among government officials, broadcasters, and hardware vendors when some of the benefits became clear. It is possible to transmit pictures and sound of significantly higher quality in the same 6 MHz spectrum that analog television (TV) occupies. Digitally encoded TV could provide new services, such as Web access via TV or interactive TV. Digital TV offers greater security to the programmer and the network. Digital techniques, such as the Data Encryption Standard (DES), double DES, and triple DES give operators hope that they can secure their pay-per-view content. Since digital TV occupies less bandwidth per program, broadcasters, satellite operators, and cable operators have the opportunity to offer more channels [1,2.3]. Instead of a mere 10-13 channels available over the air in a single metropolitan area, it is possible to have perhaps 60 or more over the air channels. Digital television is the capture, production, distribution, and broadcast of programming in a digitally encoded format. Whereas today's analog TV transmits in amplitude modulation, DTV would use Quadrature Phase Shift Keying (QPSK), Quadrature Amplitude Modulation (QAM), or Vestigial Side Band (VSB) modulation techniques.

Figure 1: Different video scanning formats for digital television

This section will familiarize you with the basic building blocks of a digital television broadcasting as shown in figure 1 and the functionality of each format [4, 5]. The vernacular to describe the formats typically indicates the number of vertical lines and the scanning format. For example, "1080i" refers to 1080 lines, interlaced scanning; "720p" refers to 720 lines in progressive format. In practice, only a few of the 18 approved formats are under consideration by the nation's broadcasters. National broadcasting commission (NBC) has declared it will support 1080i. ABC is opting for 720p, and Fox has opted for 480p. System 3 (S3) with 1920 horizontal samples and 1080 active lines in progressive scan and a frame rate of 25 Hz, 16:9 aspect ratio, abbreviated 1080p/25. System 4 (S4) with 1920 horizontal samples and 1080 active lines in progressive scan at a frame rate of 50 Hz, 16:9 aspect ratio, abbreviated 1080p/50.Most of the other elements were quickly resolved. Modulation scheme, transport, multiplexing, compression, timing, and an overall systems and testing procedure were agreed to. The apparatus for DTV was in place, almost for the past one decade but paucity of funds has impeded its smooth transmission across the entire country. Some view DTV as synonymous with high-definition television. It is not. DTV encompasses both High-Definition TV (HDTV) and Standard-Definition TV (SDTV) [6. 7, 8]. Hence HDTV is a proper subset of DTV. The difference between HD and SDTV is not standardized, but our definition of HD includes the display formats that have 720, 1080 or 2160 lines. Formats with fewer lines are standard definition. Progressive scan rewrites whole screen at one pass, interlaced scan rewrites half the screen. Progressive-scan draws all the lines of moving pictures in a sequence, interlaced draws odd or even lines at a time. Flickering is more common in interlaced display [9]. But anti-aliasing and interpolation techniques have helped reduce flickering. Progressive scan has higher vertical resolution, consequently requires higher bandwidth for same no. of frames as interlaced. System outlined in the ATSC standard is based on the motion picture expert group (MPEG-2) Main Profile and MPEG-4 Profile. Video formats span the range of Main Level to High Level. Audio Compression is based on the Dolby AC-3 system with sampling rate 48 kHz and perceptually coded [10, 11].

II. MATERIALS AND METHOD

In the course of this study, a lot of materials were used to generate and receive data used in this analysis and such materials used in signal receptions are as follows [12, 13]:

(a) Television: It was used at the nine selected locations in Enugu to monitor the video and audio qualities of the received signal.

(b) Set top box: It is the decoder used at the ten selected locations in Enugu to measure the signal to noise ratio (SNR), bit error rate (BER), channel frequencies of the different stations. Whereas, the figure 2.1 showed the materials used in signal transmission to the larger audience.

(c) Video analyser (Oscilloscope): It was used to measure the received video signals at the ten selected locations. It was used mainly in analyzing the analog video received since the set top box can always display the video quality at any of the selected ten locations.
(d) Sound meter: It was used to determine the quality of sound received at each of the selected ten locations.

2.1 Equipment lay-out

When discussing the equipment, it must be repeated that the stations are unmanned, and for this reason, all equipment must be able to operate under conditions of failure. This may require additional standby units or some internal method of ensuring continuous operation. This is termed redundancy technique. The equipment lay-out is as shown in figure 2.1

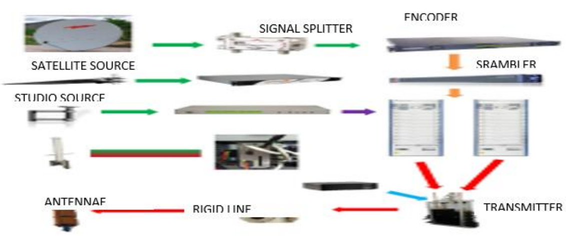

Figure 2.1: Equipment layout

2.2 The Signal Generation

Signals (video and audio) are produced in a studio where the conditions can be controlled and meet the high standard of requirements for productions with the best sound and picture quality. This requires the use of microphones, video cameras, recorders, CD and Video systems along with a multitude of other equipment. Operations are not directly involved in this portion of the process. It is our function to take the produced programme and distribute it to the viewers around the country. The studio has the task of packaging the programme to be broadcast [14]. This requires:

- Presenters introducing programmes and other items
- Playing of pre-recorded contributions from storage devices
- Inserting advertisements at the appropriate times and
- Crossing to live inserts or clips from outside broadcast facilities.

All of these materials are packaged and sent to the transmitting sites for distribution.

2.3 Command Centre

The Command Centre operates 24/7/365 and responsibilities include:

- Monitoring of all our transmission platforms and react on incidents by either rectifying themselves or escalating to a standby engineer.
- Switching services on and off, i.e. channels that do not run 24 hours.
- Insert/remove products, mainly for Global Access (An outside Company delivering a service for various companies, such as Absa, SAPS, etc)
- Respond to email, web queries.
- Keep the business informed of what is happening on our transmission ENCODER
- Quality monitoring of video and audio (Sample checks).
- Reports to platform owners and other stakeholders.

Thus the centre's responsibility is to monitor the signals that are being received from the transmitters serving the public. This closes the loop and ensures quality transmissions at all times [15, 16].

2.4 Distribution Medium

Distribution by air as a medium, requires the use of a high frequency carrier as a vehicle, and can be imagined to be a bus. Since high frequencies cannot be heard by human beings, it is ideal to use as a transport medium. It transports the content (imagined to be school kids in the bus) from one point to another, since this high frequency signal (the bus) can travel further than we are able to shout or even see. Hence, digital television transmission uses ultra high frequency (UHF) though it has increased path loss with reduced coverage distance when compared to very high frequency (VHF). Though VHF has reduced path loss and higher coverage distance but it cannot be used in digital television because of its noisy nature which will interfere with the digital signal. There are two methods that can be used to distribute the signal from the studio to the transmitter stations [17].

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2.5 Microwave Systems

Microwave systems are often used for the purpose of getting the signal to its destination in a wireless format. These signals cannot be received by standard radio or televisions set, but operate in much the same manner. They are used mainly when the feeding station and transmitter are in close proximity and usually in direct line of sight (i.e. you can physically see one from the other). Microwave links use extremely high frequencies (EHF).

2.6 Satellite Signals

Satellite signals work well for point-to-multipoint requirements such as getting the signal to many transmitters simultaneously. This type of distribution is often preferred as it best suits our needs and is in our own control.

III. THE IMPLEMENTATION PROCESSES

Terrestrial broadcasting is the distribution of audio and video content to a dispersed audience via transmitters to a large area with a signal to be received by the public, on either stationary or mobile receivers [18, 19, 20].

3.1 Digital video broadcasting- terrestrial (DVB-T2) and Digital video broadcasting- handheld) DVB-H

Frequency allocation is on VHF (174 to 260MHz) and UHF (470 to 860MHz), and also requires a large number of transmitters to cover the required area. Due to the wide range of frequencies, colour coded aerials which are cut to the specific wavelengths are required to receive good signals. Broadcasts can be free to air or scrambled (encoded) allowing better management of fee collections by addressing decoders individually [11].

3.2 Link Budget

The first step in designing a satellite network is the calculation of a satellite link budget as shown in figure 3.1. This will determine what size of dish to use, power requirements, link availability and bit error rate. It involves a relatively simple addition and subtraction of gains and losses within a radio frequency (RF) link.

Received Power (dBm) = Transmitted Power (dBm) – path losses (dBm)

When these gains and losses of various components are determined, the result is an estimation of end-to-end system performance in signal level at the satellite receiver or very small aperture terminal (VSAT) terminal receiver. To arrive at an accurate answer, factors such as the uplink power, amplifier gain and noise factors, transmit satellite dish gain, slant angles and corresponding atmospheric loss over distance, satellite transponder noise levels and power gains, receive satellite gain and amplifier gains and noise factors, cable losses, adjacent satellite interference levels, and climatic attenuation factors must be taken into account. The gain of a dish increases as the frequency increases. The actual gain depends on many factors including surface finish, accuracy of shape, feed horn matching and size of the dish. The quality is measured by the Bit Error Rate (BER). If we want our signal to have a low BER, we would start it out with higher power and then make sure that along the way it has enough power available at every stop to maintain this BER [20, 21].

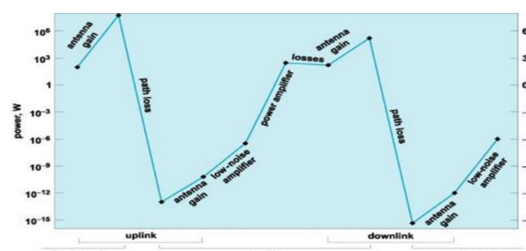

Figure 3.1: Link budget

3.3 Digital Penetration in Enugu

From the purchase and installation of set top boxes from 2010 till date, it was discovered that there was geometrical increase in the digital deployment over the last decade in Enugu due to the associated benefits of digital terrestrial television and the result was discussed in the subsequent section. The digital penetration of terrestrial television in Enugu was also monitored at the control centre of national broadcasting corporation (NBC) as shown in figure 3.2.

Figure 3.2: Equipment for monitoring digital penetration in the control centre

3.4 Calculation of Channel capacity of Analog Terrestrial Television reception over selected locations in Enugu.

The different Signal to noise ratio (SNR) of the received signals were measured at the nine different locations mentioned in section 4.4 as shown in the subsequent section and the channel capacity was calculated at each of the nine locations based on Shannon channel capacity of equation (3.1) [22 – 23]. Also the SNR is calculated using equation (3.2).

$$C = \log_2(1 + SNR) \quad (3.1)$$

Where C = Channel Capacity, SNR = Signal to Noise ratio.

$$SNR = 10 \log_{10}(\frac{Ps}{Pn}) \quad (3.2)$$

Where P_s = Signal received power and P_n = Noise power. Hence, as the SNR continues to decrease with distance, the channel capacity to carry useful signal also decreases. This trend continues until at a point when the $P_s = P_n$, then SNR becomes zero and also the channel capacity to carry useful signal drops to zero.

3.5 Calculation of Channel capacity of Digital Terrestrial Television reception over selected locations in Enugu.

The received signal power at any location is the difference between the transmitted power and the path loss as represented in equation (3.3). Received power can also be calculated using equation (3.4) [23].

$$\text{Pr} = Pt - Pl \quad (3.3)$$

Where Pr = Received Power, Pt =Transmitted Power and Pl = Path Loss. The transmitted power used was 3500KW.

$$\text{Pr} = \frac{(G \times Pt)}{F^2 \times d^2} \quad (3.4)$$

Where G = Antennae Gain, Pt = Transmitted power, F= Frequency, D = distance from the antennae.

Gain (G) of an antennae is determined using equation (3.5), where P2 is the power output in the desired direction and P1 is the isotropic radiating power (power to be radiated if the energy were to be radiated equally in all directions).

$$G = 10\log(P2 / P1) \quad (3.5)$$

In digital transmission, the SNR is replaced by Bit error rate (BER) which is the ratio of bits received in bad condition to the total bits transmitted. Hence, the BER replaces the SNR in the Shannon capacity of a channel as shown in equation (3.6) and SNR is inversely proportional to the BER. Also, BER is inversely proportional to Shannon Hartley Channel capacity as shown in equation (3.6).

$$C = \log_2(1 + BER^{-1}) \quad (3.6)$$

IV. RESULTS AND DISCUSSIONS

4.1 Result of Digital Television Penetration in Enugu

From the figure 4.1, it was shown that before the digital switch over in Enugu, there was little digital penetration of just 5% with analog television viewership surpassing 95%. However, after the digital switchover in 2010, the digital viewership in Enugu increased geometrically from 5% to about 82% within a period of four years (from 2010 to 2014) due to the numerous benefits of digital television transmission and reception. However, from 2015 till date, it has witnessed a steady and almost declining penetration due to factors ranging from non availability of set top boxes, non availability of some television channels on the digital platform as a result of poor power situation in the country and some unresolved technical issues affecting customers' reception of the digital signals.

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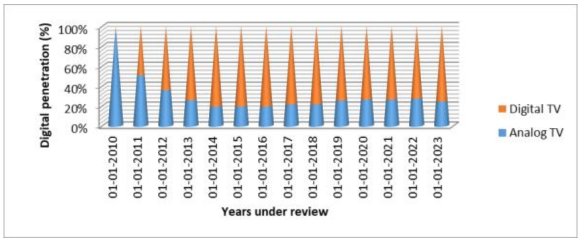

Figure 4.1: Percentage of digital television penetration in Enugu for the past ten years of digital switch over

4.2 Quality of Received Signal at the Various Selected Locations in Enugu

From the figure 4.2, it was observed that after the digital television reception was monitored at different locations in Enugu, it showed steady high video and audio reception qualities as shown in figure 4.2.

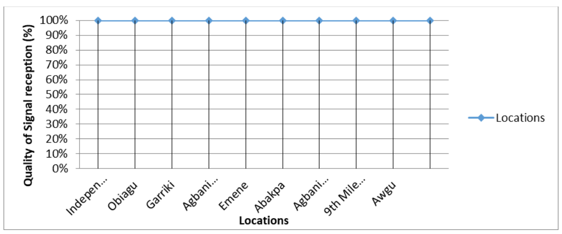

Figure 4.2: Digital television reception at different locations in Enugu

Figure 4.3 showed the analog reception over the selected nine locations in Enugu and it was observed that the old analog television reception degraded over the given location distances. The figure 4.3 showed that the signal reception started degrading from the second location (Obiagu) till it gets to the last location (Awgu). However, in figure 4.2, these locations showed very high and steady signal reception over the nine selected locations provided that the received signal power is above the receiver sensitivity.

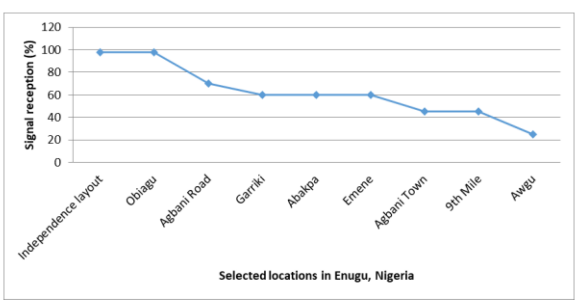

Figure 4.3: Analog television reception at different locations in Enugu

4.3 Results of Comparison of Channel capacity of Analog to Digital Terrestrial Television over selected locations in Enugu.

From table 4.1 and figure 4.4, the different bit error rates were shown and they were seen to be within the tolerable error bit rate of 9 – 10 error bits for every 100bps with high picture and audio qualities at the different locations as shown in figure 4.2. However, for analog signal reception at the same distances as shown in table 4.2, the signal to noise ratio (SNR) degraded rapidly due to the high effect of noise on analog signal as shown in figure 4.5.

Hence, increased signal power (P_s) means increased SNR while increased noise power (P_n) means decreased SNR. Also, when the P_n equals the P_s after some transmission distances, the SNR becomes zero and the channel capacity for data drops to zero and at that point the channel becomes filled with noise that the signal is completely attenuated.

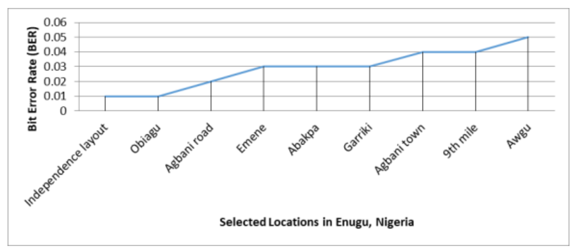

Figure 4.4: Measured bit error rates (BER) at the different locations in Enugu

Table 4.1: Bit error rate of received digital television signal at different locations in Enugu (Using 100 bps transmission rate).

Locations	Bits received in error	Bit error rates (BER)	Line of sight (LOS) Distance from transmitter (KM)
Independence Layout	1	0.01	0.90
Obiagu	1	0.01	0.90
Agbani Road	2	0.02	1.0
Emene	3	0.03	4.0
Abakpa	3	0.03	4.0
Garriki	3	0.03	4.0
Agbani Town	4	0.04	5.5

9th Mile	4	0.04	6.0
Awgu	5	0.05	30.0

Table 4.2: Signal to noise ratio (SNR) of received analog television signal at different locations in Enugu

Locations	Signal to noise ratio (SNR) in Decibel (dB)	Line of sight (LOS) Distance from transmitter (KM)
Independence Layout	27	0.90
Obiagu	27	0.90
Agbani Road	25	1.0
Emene	15	4.0
Abakpa	15	4.0
Garriki	15	4.0
Agbani Town	13	5.5
9th Mile	12	6.0
Awgu	1	30.0

Range of SNR for analog transmission varies between 1 to 30 dB but the range for optimal performance is between 18 to 30 dB. For every doubling of transmission distance, the SNR reduces by 6dB as shown in table 4.2 and figure 4.5. Hence, with the analog transmission, only people living in Independence layout, Agbani road and Obiagu received high quality signals while those living in Emene and Abakpa received weak signals. Also, those living in Garriki and Agbani town received very weak and poor signal. Then those in Awgu and environs could not receive the signal since their reception was already at the noise floor.

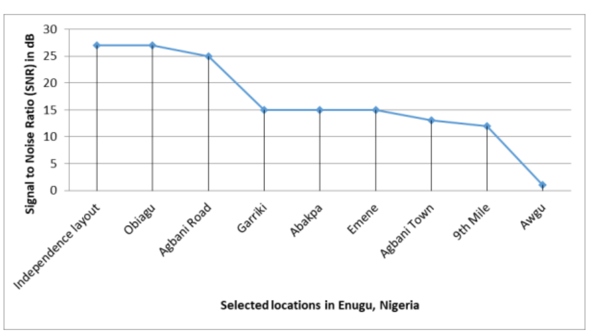

Figure 4.5: Signal to noise ratio (SNR) of received analog television signal at different locations in Enugu

CONCLUSION AND RECOMMENDATION

This paper provided the theoretical and practical benefits for the deployment of digital terrestrial television broadcasting services using Nigerian television authority, Enugu as a case study. It equally discussed key infrastructural developments in the digital switch over in Nigeria. Though the digital switch over would require huge capital investment by both the government and privately owned television stations in human and infrastructural development, the benefits of digital terrestrial television broadcasting outweigh its associated challenges. The resultant video and audio qualities generated, transmitted and received in digital terrestrial transmission were found to be of very high quality and resolution of which high definition (HD) recorded aspect ratio of 16/9, 720 lines with 1024 pixels per line, fully high definition recorded aspect ratio of 16/9, 1080 lines per frame with 1924 pixels per lines and ultra high definition recorded aspect ratio of 16/9, 2160 lines per frame and 3860 pixels per line. Also from this study, it was shown that under the same transmission power of 3.5KW and frequency of 625MHz, that the digital television services were received at improved and high signal quality in areas where the analog television services showed very poor signal quality. From the digital penetration survey, it was shown that after about 82% penetration of digital terrestrial television in Enugu, some issues like unresolved transmission problems, lack of set top boxes and poor funding of the scheme have resulted to retardation in this digital penetration. Hence, there is urgent need to resolve the above stated challenges so that the digital penetration will hit the 97% mark in Enugu and also there is need for further investments to cover the rural areas since the present deployment targets the urban centers only.

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