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Improving Transmission of Television Signals in Zimbabwe: Use of Microwave Links-Case of ZBC Harare

*[1]Lucia Winji, [2]Ruramai Muvhundusi, [3]Clopas Kwenda, [4]Gladman Jekese, [5]Gloria. E Mawere, [6]Ivy Marima
[1-6] *Department of Accounting and Information Systems, Great Zimbabwe University, Zimbabwe.*

[1]lwinji@gzu.ac.zw, [2]ruemuvhundusi@gmail.com,[3] ckwenda@gzu.ac.zw, [4]gjekese@gzu.ac.zw, [5]gmawere@gzu.zw, [6]imarima@gzu.ac.zw

Abstract
With the explosive evolving world of technology, the paradox between volume dimensions and band scarcity has notably been rising. Competition for wireless bandwidth, particularly for 5G (fifth generation) has been a major problem for unguided media and networks. To satisfy transmissions for high-definition televisions (HDTVs) while providing ultra-high-definition videos (UHDVs) in 5G networks, anticipation has been on microwave link transmission due to its massive bandwidth. This is a maiden study which aims to improve the television signal transmissions of Zimbabwe Broadcasting Corporations (ZBC) by introducing microwave links to minimize system downtimes and overload in TV signaling currently experienced with radio links and fiber optic cables. The case-based study followed a mixed research approach with interviews and questionnaires done to 30 respondents in the production, IT, and programs department at different levels across ZBC Harare. The results were analyzed using SPSS and Microsoft Excel and the findings of the study showed that ZBC is using the fiber cable analogy television signals which are affected by such factors as high latency, fading, noise and size of antennas which lead to signal distortion and reduced signal strength. This research recommended the organization to turn a new technological launch into an event, keep the new technology on their radar and stakeholder awareness of benefits as the strategies to ensure the use of microwave link.

Keywords: *Bandwidth, Broadcasting, Microwave links, Radio links, Television signals.*

1. Introduction

The explosion of evolutions in the world of technology and rise in mobile data transmissions has resulted in the paradox between volume dimensions and band scarcity being experienced during signaling (Niu et al, 2015). To solve the major problems in transmission for high-definition televisions (HDTVs) while providing ultra-high-definition videos (UHDV) in 5G networks, anticipation has been on microwave link transmission due to its massive bandwidth *(*Chien, 2018). Latest developments for ideal standardized television technology broadcasting involves the Internet protocol television (IPTV) which is now overly subscribed in distance communications using transmission mediums with greater speeds.

Joseph (2007) states that viable technology involving fiber, local exchange carrier (LEC), T-1s, and xDSL are a great limitation to clients because of third party requirements, a situation not associated with microwave transmission connections. Microwave connections are less costly on implementation and to maintain (Joseph,2007). For increased communication capacity and realization of benefits, signaling involves connecting and switching cell locations resulting in reliable and efficient transmissions. Microwave link refers to “a communication system that uses a beam of radio waves in the microwave frequency range to transmit video, audio, or data between two locations, which can be from just a few feet or meters to several miles or kilometers apart” (Patwa et al, 2018). Microwave transmission is popular in television broadcasting because it offers distance communication from point of origin. Thus, Rundstedt (2015) accurately referred Microwave links as fixed point-to-point wireless communication systems using microwave frequencies, widely used by operators and vendors to build up backhaul communication networks to connect base stations with the core network. Deducing from the above definitions the researcher will use the definition by (Patwa et al 2018).

With the advancement in television signals communication, ZBC should upgrade to fight off system downtimes and system overload associated with fiber optical cables when physical damage occurs. (Forouzan, 2007). This gave the researcher a motive to carry out a research focusing on improving TV signal transmission in Zimbabwe using microwave link.
The aim of the study to improve TV signaling and broadcasting using microwave links will be achieved by determining the operations of television signaling and broadcasting at ZBC and will be answered by the following research questions:

1.1 Research Questions

1. Which television technology operations are used in Zimbabwe and which factors are affecting such operations in the country?
2. How can television broadcasting be improved with microwave technology?
3. Which strategies could be used to ensure the success of microwave link signaling in Zimbabwe?

This research paper is organized into three parts. Firstly, literature related to TV signals and broadcasting using microwave links will be reviewed. Secondly, research method and design will be explained followed by the major findings from the chosen case study. Conclusion will be made based on the research findings. The results of this research are hoped to be helpful to stakeholders in the Telecommunication domain particularly to the country of Zimbabwe and help improve its quality of television signals and communication.

2. Literature Review

2.1 Overview of TV Signals and Broadcasting

Television involves the remote delivery of a moving picture, plus sound (Stephens, 2015). It is accurate to think of the sound as continuous; however, the picture is captured, and then delivered, as a succession of still images, at a rate fast enough that the viewer perceives a scene of continuous motion. Simple communication involves transmitting (Tx), receiving (Rx) and the medium (Jiang et al., 2015) as illustrated in Figure 1 below.

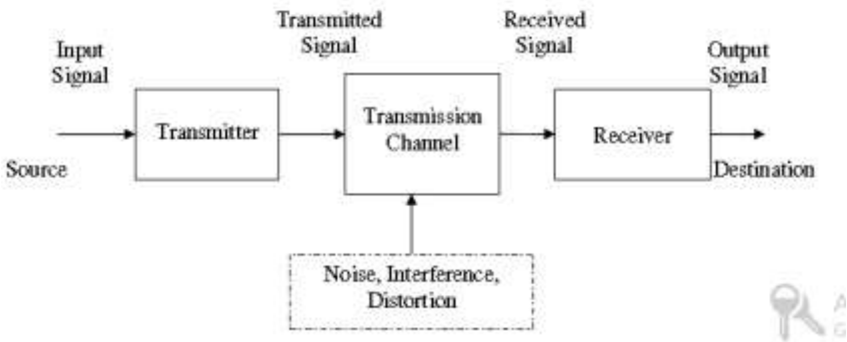

Figure 1. Overview of Radio Wave Propagation *(Source; Rutledge (2002))*

According to Jiang (2015) it is best to comprehend the media bandwidth and utilization if performance can be determined. Attenuation can be impacted upon due to transmission impairments associated with the channel and these can include noise and distortion. Forouzan (2007) explained that correct TV signals face disturbances which can be physical features such as mountains, changes in air pressure, distance among other factors which can impact on bandwidth, frequency, latency, and the overall performance to users.

When signals are transmitted over a network, there might be a reduction in signal strength due to attenuation. Forouzan (2007) explained attenuation as a negative (loss) or positive (gain) in signal strength during transmission when data is monitored and analysed at a distance.

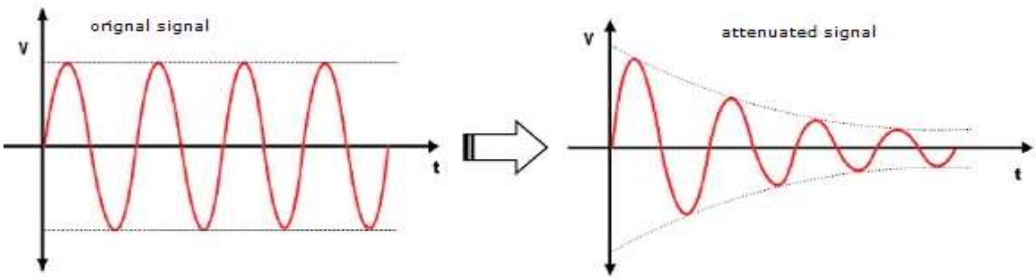

Figure 2. Original and attenuated signal *(Source; Xianzhao et al (2015))*

Xiaoyang (2017) explained that signals are weakened by resisting pressures faced within the channel. If the signal-to-noise ratio is too high, signal strength is better and may be read correctly at the destination point.

Nguyen (2014) explained that frequencies can be reduced using Attenuators which are introduced for high-level signals in a static or adjustable way. Attenuation in places with poor transmission due to low frequency can be aided with slope attenuators to ensure consistency in signal level before amplification. (Forouzan, 2007).

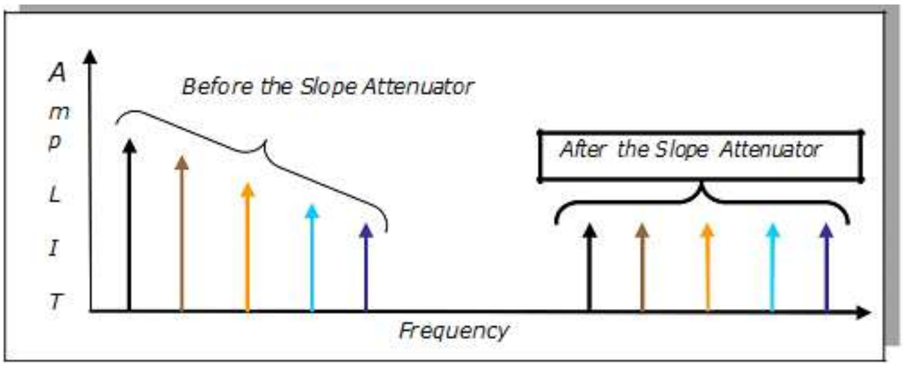

Figure 3. Slope attenuators *(Source; Forouzan (2007))*

Frequency can be also attenuated by filters which are devices used to attenuate frequencies, by either allowing certain bands of frequencies through, or attenuating a certain band of frequencies. According to Kerry (2014), notch filters are used for rejecting unwanted frequency, which can be singularized or a collection in a medium and reduce interference.

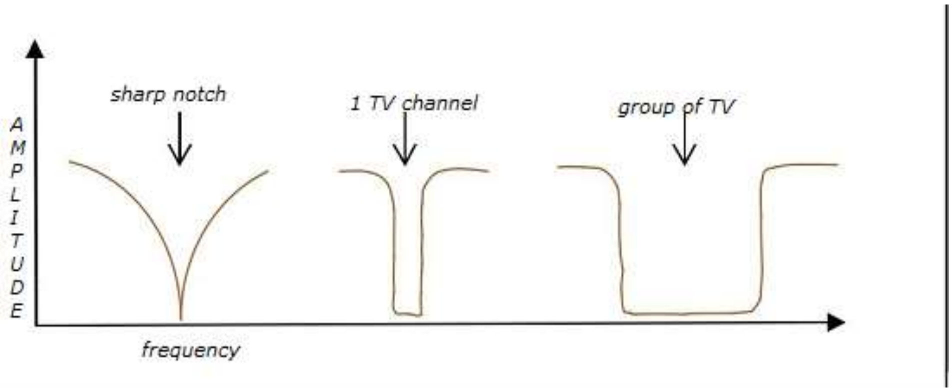

Figure 4. Notch filter *(Source; Kerry (2014))*

Furthermore, when signals are transmitted through the transmission medium they can be affected by noise during the transmission. Huang (2008) define noise as unwanted information indicators in a network which can be induced or occur through a natural cause that affect the signaling and broadcasting operations and may lead to the reduction of signal power or signal loss. According to Huang (2008) “signal-to-noise ratio (SNR) and carrier to noise ratio (C/N) are two measurements of GPS signal quality where C/N is the ratio between carrier power and noise power at the input of receiver while S/N is the ratio between signal power and noise power at the output of receiver.” Kerry (2014) states that the measurement unit of SNR is decibels (dB) where high levels in SNR results in better quality signaling with required data overriding scrap data items.

2.1.1 Bandwidth and Noise

Noise affects bandwidth range and is mostly haphazardly distributed across a channel or medium, as such, the more wide bands of frequency in a channel, the more noisy a channel becomes(Kerry,2014).

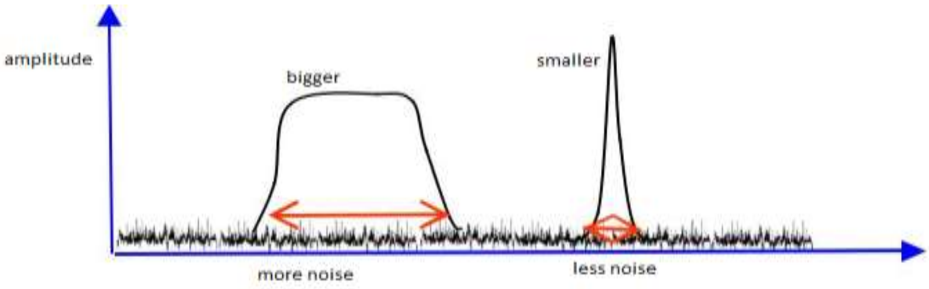

Figure 5. Bandwidth and Noise *(Source; Schaefer (2012))*

2.1.2 Carrier to Noise

When distributing or receiving signals there are two concepts involved, first, to receive a good signal, and secondly, minimized interferences which can affect signal performance. Noise levels measured in decibels against the carrier can be referred to as "carrier-to-noise ratio and is defined as the ratio of the received modulated carrier signal power C to the received noise power N after the receiver filters" (Rumsey, 2015). Such a measurement can be formulated as:

C/N (dB) = 10*log (carrier/noise)

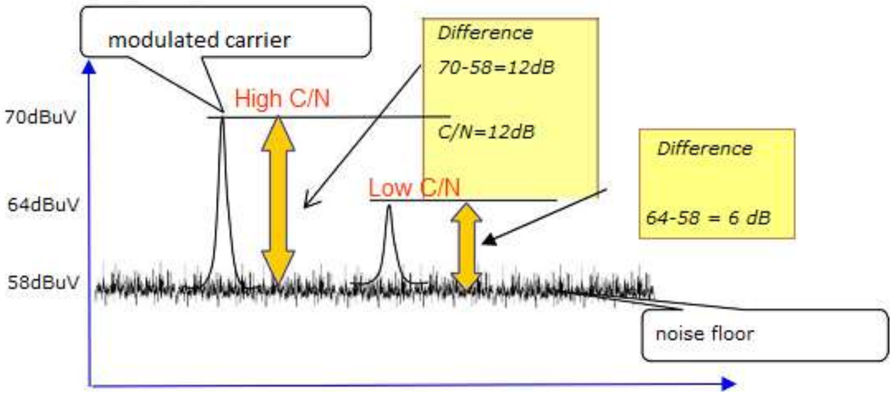

Figure 6. Carrier to Noise Ratio *(Source; Jiang (2015))*

2.1.3 Signal- to- Noise Ratio (SNR)

According to Rumsey (2015) SNR equates the strengths of a sent signal and irrelevant material within a channel, providing measurement in Db. An increment in SNR levels means gives a sound readable signal which can easily be interpreted before and after changes in the type of signal (modulated or demodulated).

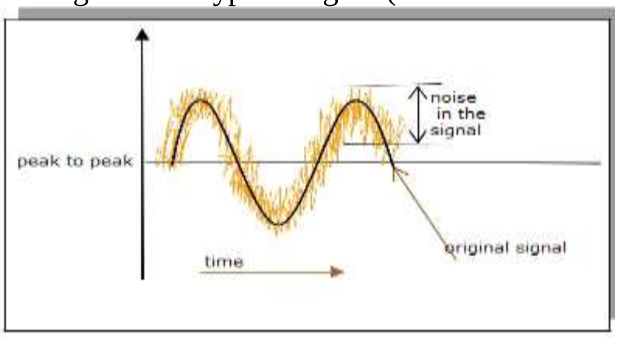

Figure 7. Signal to noise ratio *(Source; Franklin (2018))*

SNR measures and determines the uncertainties centered on a signal, a situation which can be noted in analog signaling but hidden in digital signals and only to appear when bits are recorded with errors and fail to be read. According to Elfadil et al (2013) data communication through radio signals is heavily affected by loss of energy as distance and noise levels accumulates at the destination point, resulting in need of modifications for data when sending or receiving.

According to Mukarakate (2015) television broadcasting in Zimbabwe still involves both analog and digital communication and there exists now, a coordination of integrated varying technologies for television broadcasting. Deviations in signal attenuation, that is the steady loss in energy, is referred to as fading (Kelechi et al 2014). Fading fluctuates with the environment the signal passes through, period and number of occurrences. According to Kelechi et al (2014) fading is caused by multipath propagation (spreading) or shadowing, which can intensify the percentage of error occurrence in data at the receiver. This multipath fading exhibition results in dispersed time and frequency domains in wireless systems, and signals from such various paths interferes positively or negatively to mobile communications.

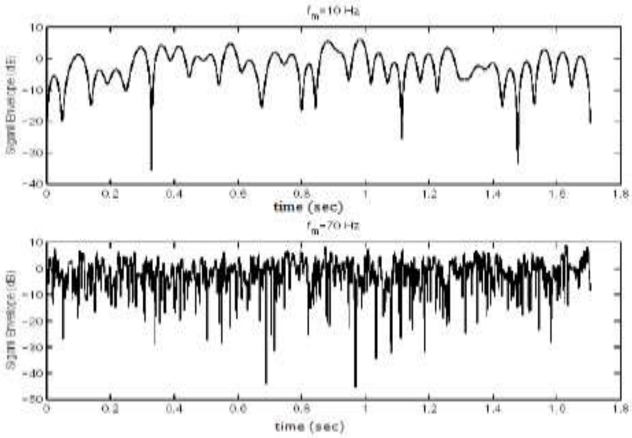

Figure 8. Fading signal *(Source; Mahender et al (2018))*

When interference occurs and causes distortions within the signal on different locations, it is best to implement radio wave links which minimizes such negative disruptions to the signal and the data that will have been sent (Mahender, 2018).

TV signal distortion due to fading is low in Microwave links. This was supported by Rakib et al (2009), who explained that microwave links are so adaptable and offers broadband, thus huge amounts of data can be transferred at greater speeds. Transmitters in microwave generates energy for required frequency and modulates the power levels. Interference is managed at microwave link receiver. Furthermore, Shabbir (2009), states that “in radio communication medium frequency (MF)/ High frequency (HF) band,” is different for certain periods and with changing patterns of weather enhancing the fading effect. Microwave technology is broadly in usage for communication between two points because of their small wavelength which permits for convenience in sized antennas and directing of narrow beams focused on the receiver. Weather conditions like smog, rainfall, and snow are not a limitation to the microwave power transmission.

Microwave link allows frequency reuse (Bakalela, 2017). According to Bakalela (2017) frequency reuse is a technique for using specified range of frequencies (to minimize interference) more than once for the same radio system to increase total capacity with the same allocated bandwidth. Hindia (2015) stated that frequency reuse schemes require self suffient isolated signals using the same frequencies to minimize interference among them. Frequency reuse allows Worldwide Interoperability for Microwave Access systems (WiMAX) operators to be used involving frequency reuse in various places (Hindia, 2015).

2.2 Importance of Microwave Link

Shabbir (2009), highlighted the importance of microwave radio compared to cabling transmission as follows:

i. Fast implementation which takes less than 24 hours
ii. Consistent and dependable communication compared to Radio communication which is affected by the outside environment to cause fading. Fading is minimal because of propagated microwaves between the communicating points.
iii. Little or no barriers to communication since microwave links overcomes geographical features like terrains and roads and access can be done at minimum costs and in shorter periods.
iv. Agility in microwave radio transmission enhances extension of link dimensions at lesser costs and changes can be implemented according to user needs.
v. Simplified inter-city access to terrain and construction of Microwave links where tunneling is prohibited.
vi. Microwave links infrastructure can exist in isolation and is not dependable on other operators or rivalries in business.
vii. Easily maintainable with problems being fixed in very little time.
viii. More flexible particularly in times of natural tragedies

Shabbir (2009), edify microwave benefits from broadband perspective including transmission of huge volumes of data at greater speeds with very limited requirements in point-to-point connections. According to Wei-Jia et al (2017), volumes of data can be transmitted because of high data rates and the use of repeaters enables communication in large geographical areas. In Europe, greater speeds in which microwave links travel when compared to fiber cabling were realised. The delays in transmission time between the sender and receiver is much less in microwave links owing to the substitution of the common fiber technology in European networks. Flemming (2015), in determining the merits of microwave against fiber, realized that delays in microwave signals was 5.4 microseconds yet in fiber, beam of lights move at 8.01 microseconds for each mile. Microwave is thus preferred since it reduces the delay when sending out data.
The technologies centered around microwave links are key driving features in developing community antenna television (CATV) which had limitations in choice

of channels aired in the early 1950s (Joseph, 2007). Only within a distance between 100-150 miles could a CATV operate and provide airing to the closest users, yet microwave links enabled the same broadcasting to distant places, including the once inaccessible areas from the source television station. It was though the introduction of microwave technology that customers had a wide range of selection programs which could be transmitted across cities.

Flemming (2017) contrasted earthly cabling technology to microwave links on which physical cabling is not required with roofs and high lying areas such as mountains providing low-cost bases for microwave towers. This means the use of microwave link will enable ZBC to reach rural audiences, thereby increasing its market share. Adding to this, Flemming (2017) stated that the frequencies and the propagation characteristics of microwave links enables communication to inaccessible areas thereby allowing large volumes of data transmission to be possible in the absence of cabling connections on the points.

Microwave links are critical to data communication because they enable high frequencies which provides for dependable and efficient transmission rate of signals from source to destination points. A proportionate consumption of bandwidth is achieved during modulation of signals, and this allows multiple links to be channeled using low frequency signaling. According to Shabbir (2009) and Tomsho et al (2015), microwave bands are classified differently according to channel purpose and specifications. Bandwidth utilization is done through multiplexing where middle frequencies are allocated extra bands for channel overlapping and to avoid interference between the channels. Mukarakate (2018) enlightened on the wide range of channel programs that can be available in Zimbabwe through the digitalization process currently being enrolled in the country and these can rise with extensions in the broadcasting spectrum.

3. Methodology

This study aimed to enhance the transmission processes of Zimbabwe broadcasting corporation by adoption and usage of microwave links. Interviews and questionnaires were used to gather information from 30 engineers across different levels and to compare with Microwave link specifications. Zimbabwe Broadcasting Corporations was used to carry out the study using the mixed methodologies of qualitative and quantitative research approaches.
The research classified the respondents into categories which comprised of Engineers in the departments of production, stations, programs and IT. The sample size is indicated in Table 1 below.

Table 1. Sample size

Sample group	Sample size
Stations	1
Production department	10
Programs department	7
IT departments	13
Total	**30**

4. Research Findings and Discussions

Data was collected from 30 questionnaires which were administered, and 27 responses were returned, which represents 90% response rate. Such a response rate is considered satisfactory to make conclusions for the study. Data collected was analysed using SPSS.

4.1 Television Signaling and Broadcasting Operations

Interviews conducted enlightened that ZBC is still using analog transmission in transmitting television signals and currently is migrating to a digitalized platform. ZBC Engineers expressed much concern over delays experienced during transmission of television signals. High latency was given as one most critical problem that needed to be addressed urgently since this was causing poor transmission and poor-quality signals to be received. Geneva (2018) reinforced the issues of latency stating that extreme recordings of latency within a signal signifies prolonged delivery time for data at the receiving end. This was supported by Flemming (2015) on explaining the high latency involved with fiber technology. In related literature, latency problems were reviewed by the researcher and of note was high latency in fiber cable with 8.01 microseconds over a given mile.

Figure 9 below presents the findings on the factors that have a negative effect to signals and the broadcasting process as was given by respondents from the questionnaires. Most of the people supported the highlighted factors which among them included high latency, natural disasters and frequency being the most critical factors for poor transmissions as expounded by Shabbier (2009) who stated that fiber is more prone to errors, and this can be a result of natural disasters.

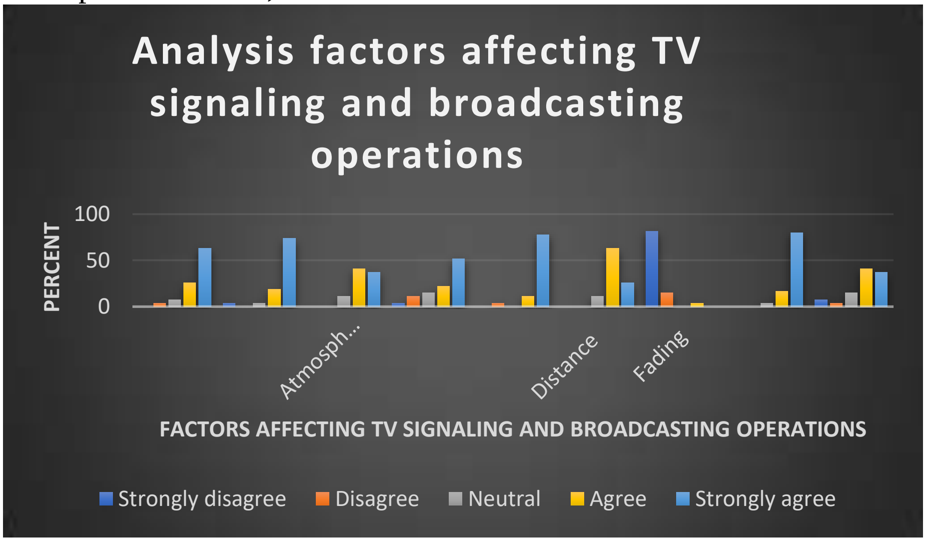

Figure 9. Factors affecting TV signals and broadcasting process

From the findings, most of the participants didn't support that poor TV transmission of signals is caused by fading. This is because climate environments with smog and snow affect Zimbabwe to very limited extents. Shabbir (2009), stated that medium and high frequency bands in radio communication, are affected by climatic conditions which necessitate "fading" Such weather conditions are rarely experienced in Zimbabwe and at ZBC.

4.2 Importance of Microwave Link Technology

The results of determining the benefits of introducing microwave signaling is shown in Figure 10 below. Most benefits of microwave link are as follows: Fast implementation which takes less than 24 hours; consistent and dependable communication compared to Radio communication which is affected by the outside environment to cause fading- fading is minimal because of propagated microwaves between the communicating points; little or no barriers to communication since microwave links overcomes geographical features like terrains and roads and access can be done at minimum costs and in shorter periods; agility in microwave radio transmission enhances extension of link dimensions at lesser costs and changes can be implemented according to user needs; easily maintainable with problems being fixed in very little time and more flexible particularly in times of natural disasters. Other respondents called for the introduction of many channels to enable frequency re-use and bandwidth utilization.

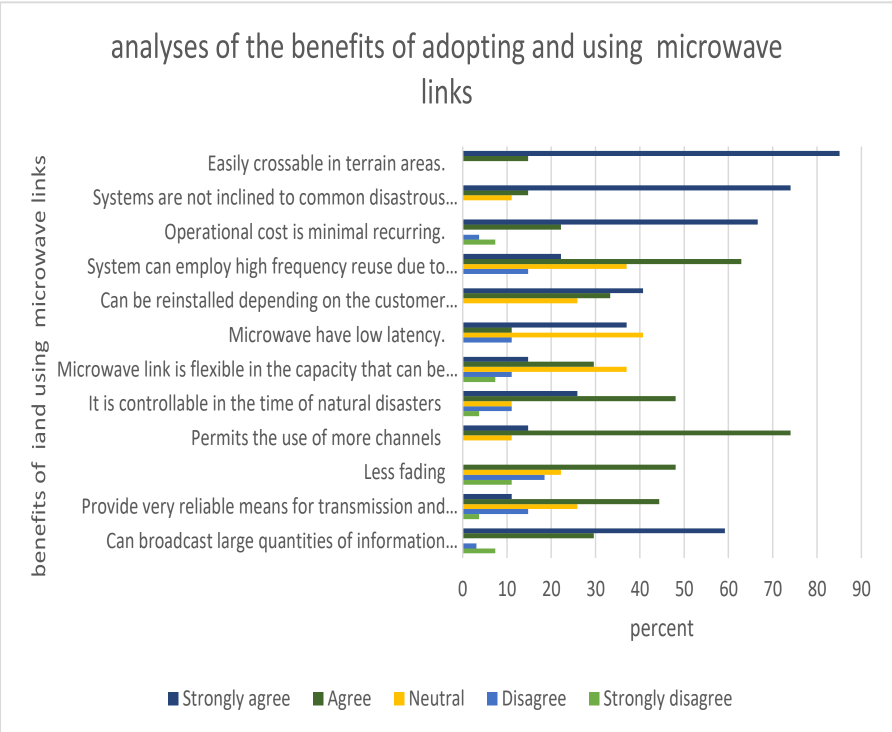

Figure 10. Benefits of microwave link

Research was done on determining the possible ways of solving the challenges stated by the engineers. Information gathered from the interviews clearly pointed the issue of latency and how it affected transmission. The reviewed importance of microwave links when compared to fiber was noted and opted for since less delays could be experienced, and signals sent at greater speeds. Microwave links during signaling, delays slightly above 5 microseconds compared to fiber which delays with more than 8 microseconds within a given mile (Flemming, 2015).

It was noted that signaling should be efficient and reliable to the ZBC stakeholders and problems currently experienced with signal reception in different parts of the country could be solved with microwave links. This was reinforced by Flemming (2015) on contrasting other technologies with regards to lower frequency ranges giving rise to poor transmission rates, a different case with microwave link signals which offers higher data transmission rates owing to high frequency.

4.3 Strategies to Ensure the Use of Microwave Links

This research study focused on the strategies and approaches to improve the television signaling and broadcasting operations using microwave link at ZBC in Zimbabwe as shown in Figure 11 below. The presentations of the findings from the respondents strongly felt benchmarking is the best option with 75% while training opportunities recorded 70%. The major drivers were working with users in the use of microwave links.

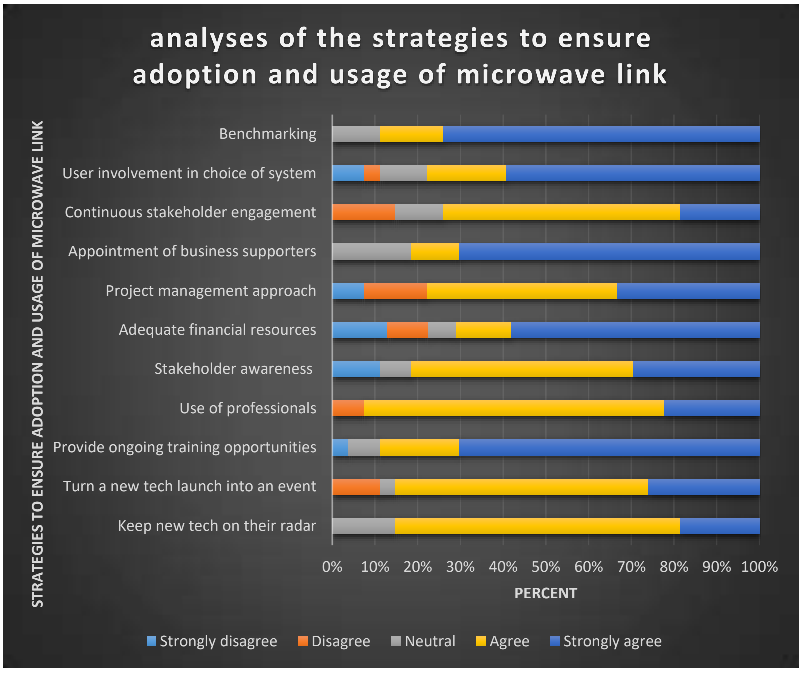

Figure 11. Strategies ensure the use of microwave link

From the interviews carried out, engineers also highlighted various ways that can be applied in the broadcasting process at ZBC. The engineers highlighted the need for stakeholder alertness and consistent involvement would support the use of microwave link technology to improve Zimbabwe programs and broadcasting.

5. Summary, Conclusions and Recommendations

From the study the following conclusions were obtained to improve TV signal transmission based on the main objectives of the research: The research aim was focused on improving ZBCTV signaling and broadcasting operations using microwave links.

From the findings, several factors were identified that impacts on Television signaling and broadcasting at ZBC. Among the major factors noted, the issue with high delays during data transmission was given, fading and bandwidth. Attenuation was noted to be caused by such noise from random movement of electrons (thermal) and changes in air pressure that the signals face while in transit. Additionally, the dimensions of the antenna also impact transmission of signals. It was also highlighted those natural disasters affect television signaling and broadcasting operations.

From the research done, ZBCTV broadcasting problems solutions exists within the usage of microwave links as engineers opted for the already identified benefits and importance of microwave technology. Microwave use sounded the best alternative currently available to ZBC, thus should be adopted.

The interviews held and questionnaires findings recorded benefits which included: movement of large volumes of data owing to increased rates of frequency, efficient and dependable transmission associated with less delay since microwave offers greater speed transmission levels to data. Multiple channeling through multiplexing is possible because frequency re-use option is available in microwave link signals. Microwave links have no limitations to physical places and features like roads and terrain compared to fiber technology which requires physical plant requirements to operate and can be destroyed by natural disasters.

6. Recommendations

According to the research findings concluded for this study, several suggestions have been proposed by the researcher to assist ZBCTV achieve its goals in improving signal transmission and connectivity while providing quality programs:

6.1 Stakeholder alertness to Microwave technology

Although ZBC is aware of this technology, they should pay more attention to usage of microwave signaling, utilization, high throughput accompanied by less cost and the rection in operational costs.

6.2 Accept and turn new technology into a reality

The technology should be shared across with sister companies and Zimbabwe at large while notifying them of the great benefits within digitalization process compared to analog. The stakeholders should support the technology and enjoy quality production in Zimbabwe just like other countries.

6.3 Keep new tech on their radar

New technology should be adopted and used with consistency in order to achieve the best results. A positive attitude should remain within the organization and users of the system to achieve a successful project. Once adopted, there should be no turning back for the betterment of transmission levels in the country.

6.4 Benchmarking

Comparison should be made to television signaling in sister countries and broadcasting at national level because ZBC is national TV station in Zimbabwe. More channels should be launched in order to satisfy customer tastes.

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