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Examination of State of Art Technology in Digital Television Transmission in Ghana: Case Study of Knet Limited

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Abstract

Digital Television Transmission (terrestrial, cable and satellite) is believed to be the way forward in television transmission, a paradigm shift from analogue television transmission. This study examined the state of art technology of digital television transmission and assessed Ghana readiness for the national switchover to the Digital Terrestrial Television platform (DTT), financial and technical challenges, and the need for Ghana to transition per International Telecommunication Union (ITU) - Geneva 2006 (GE06) agreement. To achieve these, qualitative research approach was adopted using case study since there is limited knowledge on this study by sampling (purposive and snowball) respondents to obtain data on Ghana DTT infrastructure, continuous development and transmission perspectives. The results obtained revealed Ghana has delayed significantly in transitioning from analogue to digital platform which was set for 17th June, 2015 per International Telecommunication Union (ITU) Geneva 2006 (GE06) agreement, with only 2 of the 42 transmission sites up at the time of this research, due to financial constraints, DTT project infrastructural variations (transmission mast and shelters), and unavailability of electricity to power the transmission sites. It also came to light that broadcasters could not harness the full benefits of DTT in form of reduced operational cost, signal quality, coverage etc. since most of the DTT sites are not up; intense educational campaign on digital terrestrial television broadcasting in Ghana is yet to commence and continuous development of DTT has been provided for with Ghana DTT platform being software upgradable. Project planning is therefore recommended to reduce contract variations and cost overruns to the barest minimum; the completed DTT sites should be maintained to ensure that they are in technically acceptable condition before they are powered and immediate steps should be taken to power all sites to enable Ghana harness the full benefits of DTT.

Keywords: Television; Technology; Digital transmission

Introduction

Digital Television Transmission is the streaming of impairment free digitally processed and multiplexed signals in a binary on/off bit sequences to all receiving locations within coverage area [1]. Television signal whether digital or analogue can be delivered through three main platforms; cable, satellite and terrestrial wireless. Digital Cable Television Transmission is the transmission of television signals to receivers through direct cable connection from an underground cable network with improved interactivity and has a higher multiplex capacity compared to terrestrial digital television [2]. Digital Satellite Television (TV) transmission is the transmission of digital television signal from a base station towards a satellite which is then processed and converted into frequency range that can be viewed using parabolic antenna [3] and has the benefit of reduced transponder cost and increased channel capacity for given transponder space [2]. Digital Terrestrial television transmission is seen as the most important means of delivery of digital television signals, provides real and non-real-time delivery of content, point-to-multipoint and one to many architecture, delivering geographically local content and supports receivers that can move, free to air and subscription services [4]. The terrestrial digital compression technology allows many channels to be broadcasted with the same amount of spectrum used by one analogue channel and receiving of digital signals on conversional television aerial by conversion into analogue by a set-top box (STB) or viewed with integrated digital television set (IDTV) [2]. Digital Terrestrial Television is the transmission of digital television signals from a ground based transmitter operating in the UHF or VHF band which is radiated as radio waves and are received using a UHF or VHF antenna [1]. Digital television transmission is the new wave of broadcasting and the future of television broadcasting [4]. It has naturally evolved from Analogue Television Transmission and involves the process of generating television contents, editing, finalizing, storing, transmitting and receiving just like in the analogue system. In digital television transmission, all the processes are digital based; image, sound and information are generated and received as digital signals unlike Analogue Television Transmission where content generation and transmission are through analogue signals [5].

Analogue television transmission involves the dissemination of analogue television signals over three main paths; terrestrial transmission, via satellite and broadband cable paths [6]. Terrestrial analogue television transmission is the oldest and most commonly used technology which uses ultrahigh frequency (UHF) band, has limited electromagnetic spectrum and as a result, only a very limited number of channels can be transmitted analogically [2]. Cable analogue television transmission streams television signals through cable technology and enables more channels to be transmitted compared to terrestrial technology, and is best suited for predominantly densely populated urban areas where building cable networks is economical [2]. Satellite analogue television transmission involves streaming of analogue television signals over satellite, it was developed with rural television viewers in mind who had limited access to other platforms and could purchase large and expensive parabolic antennas. For reception of

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analogue satellite signal, there a need for a clear line of sight from the receiver (dish) to the transmitter satellite [2].

In analogue transmission, each channel had a dedicated frequency and satellite transponders and was fraught with a lot of challenges such as limited frequency, linear editing, and huge capital investment by broadcasting stations in transmitters & supporting technology, poor storage of television content, noisy signals because of environmental interference and high energy consumption. Prior to the mid-nineties, television transmission around the globe was purely founded on analogue electronics, and transmission equipment voltage was proportionate to sound pressure or light. These challenges led International Telecommunication Union (ITU) to outline in their report entitled Trends in Broadcasting: An Overview of Developments (February 2013), how to deliver improved broadcasting service in an efficient and cost-effective way taking into consideration: local market requirements; existing transmission networks and receivers; alternative means of content delivery, including broadband, via mobile, fixed and satellite networks; regional and international regulatory requirements regarding the use of the frequency spectrum; existing broadcasting transmission standards and future developments; and demand for spectrum from other than broadcasting services.

Problem statement

The government of Ghana through Ministry of Communications signed a contract with K-Net Limited on 17 July 2015 for the supply and installation of a national digital terrestrial television network solution, to be delivered by January 2017 (KNet Contract Document, 2015). Unfortunately, the delivery date was not met due to technical, transmission and financial constraints and the switchover date has been changed to the second quarter of 2018. Since the start of the contract implementation, no scientific study has been undertaken to assess Ghana readiness for the switchover, the effect of Ghana paradigm shift from analogue to digital television transmission on stakeholders, and the availability of digital transmission infrastructure for a sustainable transmission of digital signals.

Research aim and objectives

From the research questions under consideration, the aim of this study is therefore to evaluate the state of art technology of digital television transmission in Ghana. To achieve this aim, the following objectives would be carried out to:

- Assess whether Ghana DTT infrastructure and transmission of digital signals meet expectation as stated in the DTT contract with KNet Limited;
- Assess how transmission of digital signals has improved television transmission in Ghana.

History of Television Transmission – Analogue

"For ages Man dreamt about the possibility of transmitting pictures over great distances, but not until he had learnt to master the electron was there any real hope of turning the dream into practical reality" [7] According to Peters (1985) of European Broadcasting Union (EBU) in a publication entitled *A History of Television,* the idea about television transmission was discovered by Joseph May, an Irish in 1873, and stated that "photoelectric effect: selenium bars, exposed to sunlight, show a variation in resistance which can be transformed into electrical signals" and transmitted. This served the base for further development by pioneers such as George Carey (1875) Boston, USA, Constantin Senlecq (1881) France, Paul Nipkow (1884) Germany, until 1897 when Karl Far Ferdinand Braun of University of Strasbourg invented the cathode ray tube with a fluorescent scene that made electron beam move horizontally and vertically and had the effect of tracing visible lines on screen. The cathode ray tube was further worked on by Boris Rosing (1907), a Russian scientist who suggested that it might be used as a receiver screen, of which A. A. Campbell Swinton (1908) a Scottish, made electronic proposal on using cathode ray tubes at both sending and receiving end of signals and in (1911) where the image is thrown onto a photoelectric mosaic fixed to one of the tubes, a beam of electrons then scans it and produces the electric signals and at the receiving end, the electric signal controls the intensity of another beam of electrons which scans the fluorescent screen.

These science inventions of analogue television transmission evolved until 1926 when John Logie Baird an electrical engineer from Scotland came out with the first transmission of a real scene of a head of a person, of which Denes von Mihaly (1928) of Germany and Rene Bartholemy improved on significantly and soon caught up with a lot of people, manufacturers and states. Science matched on until the first television transmission in March 1935 in Berlin, followed by Paris in 1935 and Britain in November 1936 etc. The television transmission since then was based on analogue system which transmits only black and white signals, there was however a radical change in the 1950's about the invention of colour television transmission based on the works of Baird in 1928.

The invention of Colour Television Transmission started when H.E. Ives and his colleagues at Bell Telephone Laboratories in (1929) picked the works of Baird and developed a "system using a single spiral through the hole of which the light form three coloured sources was passed" [8]. Further works were done by George Valensi (1938) in France who proposed the dual compatibility principle, stating that "programmes transmitted in colour should also be received by black white receivers" and "programmes transmitted in black and white should also be seen as black and white by colour receivers" [8]. Peter Goldmark (1940) of CBS United States demonstrated a less successful system of colour television transmission using three colour filters placed in the light path before scanning. The final breakthrough was recorded in 1953 by RCA and Hazeltine Laboratories in the United State which established that signals are no longer transmitted in the form of three primary colours but a combination of the primaries which can be by existing black and white receivers, and was later perfected by Henri de France (1961) and Dr. Waiter Bruch (1963) which resulted in the successful launch of coloured television service in England, Germany France in 1967. Analogue television transmission is done over either of three transmission paths, via terrestrial transmission, satellite transmission or broadband cable, the path chosen is dependent on the preference of the countries or regions concerned. The analogue transmission link is subject to interferences from the environment in the form of Linear Distortion, Non-Linear Distortion, Noise and Intermodulation which affects the quality of signals [1]. It is estimated that transmission of analogue television signals will shrivel away into insignificance within few years with Germany currently having analogue viewership population of less than 10%, the reason being the good coverage of digital transmission of signals and more programmes [6]. The continuous development of technology in television transmission led to the invention of digital television transmission which is based on computer image processing technology [9].

Broadcasting commenced in Ghana on July 31st, 1935 via a BBC wired relay station in Accra code named radio ZOY, launched by the then Gold Coast Governor - Sir Arnold Hodson, television broadcasting

however started in Ghana in 1965 (black and white television) through analogue transmission until 2008 when digital video broadcasting was introduced by Ghana Broadcasting Corporation in Accra (Ministry of Communication – DTT Draft Broadcasting Policy, 2016).

The advent of digital television transmission started in mid 1980s in Japan, however significant breakthrough was only realized in 1990s when General Instrument, an American Company demonstrated the feasibility of a digital television signal [8]. Coupled with the numerous advantages outlined in the background of chapter one, many countries around the world under the guidance of the International Telecommunication Union (ITU) started switching over from analogue to digital platforms of which ITU has set 17 June 2015 under the Geneva 2006 Agreement (GE06) as the final switch-over date of its member states. Digital television transmission is the new order around the globe in transmitting television signals; this new paradigm is changing the lives of people by giving subscribers the opportunity of more programmes from different channels, picture quality, and clearer sound etc., [5]. According to ITU report on Spectrum Management (2015) the main purpose of the global migration to digital platform is to ensure maximum efficiency in transmission and spectrum usage which served as the main driving force for the GE06 Agreement to which Ghana is a signatory. Going by the background given, Ghana is at the threshold of breaking new grounds in digital terrestrial television broadcasting which could lead to massive growth of television broadcasting alongside tremendous economic and social benefits through the establishment and operation of DTT platform by KNet Limited. KNet Limited is a Ghanaian owned company established in April 27, 1999 and has enormous experience in the provision of VSAT and DTH platforms. It provides DTH platform to television broadcasters such as Multi TV, Ghana Television (GTV), and TV3 etc. and has over 2,000,000 viewing Ghanaian household. (Hlomador 2013 – Chief Architect, KNet Limited Presentation on Digital TV Migration in Ghana).

Digital Television Transmission (DTT)

This is the transmission of television signals through digital processing by ground based television transmitters. It is viewed as a completely new way of broadcasting and the future of television transmission (Australian Broadcasting Authority – Canberra, 2005). In reality, the difference between the concept of digital television transmission system and analogue transmission system is the details of implementation. A typical television transmission system is comprised of an exciter, power amplifier, radio-frequency (RF), antenna with associated transmission lines and receiving locations. The broadcast transmission path is between the transmitter and the receivers of which the baseband signal is inputted for modulation by RF carrier [1].

The baseband signal of the analogue system includes composite video signals and audio signals which in separate amplification modulate separate visuals and aural carriers and in common amplification, the modulated signals are combined in the exciter and amplified together in the power amplifier and the combined signals transmitted together through the remainder of the links. With the digital transmission, the exciter used with the transmitter is different and the carrier is modulated by a single composite digital baseband signal, amplified in the transmitter, broadcast through the antenna and received after circulating through over the air link of which the data stream includes video, audio as well as data. The digital transmission also has subtle differences to the analogue transmission in relation to power measurement, tuning, control, performance measurement, up converters, power amplifiers, transmission lines and antennas [1].

In digital transmission, data bits are produced by a binary source modelled by a binary generator block, the data are then coded which are obtained by punctuating bits which are interleaved with a turbo-based algorithm and then mapped to subscribers for modulation. Transmission line is important for a successful digital television transmission in handling transmitter power, linear distortions, modulated signal, and wind loading to transmitter tower [1]. *In digital systems, simultaneous transmission node within one frequency channel is used to deliver data streams containing packets generated from audio and video information from one or more programmes (Pr. 1, Pr. 2 …Pr. N), and additional data streams, with virtual time and frequency bandwidth and segmentation* [5]. Digital signal processing techniques provides components for simultaneous transmission of multiple programmes and data reduction methods based on redundancy specifics for certain type of media such as visual redundancy and statistical redundancy etc. which makes it possible for efficient use of radio spectrum and channel capacity required for information transmission [5].

The picture brightness element along a television line can be represented by a series of numbers and each value can be transformed into a sequence of electrical pulses. It is two staged process which involves measuring sample values at regular intervals and conversion into binary numbers in digital television transmission. It is an extension of the computer and image processing technology and huge storage capacity, and has an isolated picture element that can be called up independently [9]. Digital transmission technology is based on broadcasting audiovisual media such as video, audio, data (teletext, subtitles closed captions or an EPG information by bit streams. The digital broadcasting migration process has been basically the same from continent to continent. In Africa, the technology, regulatory and legal reviews and implementation plans are the same. The major difference is in the method of funding. The technology used allows for transmission of technical metadata for programme identification and receiver configuration and access to services such as audio-description or sign language incorporated within the transmission multiplex signal and delivery to end-users. Interoperability is an important concept in transmission/broadcasting where different systems/element can be interlinked and digital television system has two basic components namely Generic Element and Application-Specific Elements. The Generic Element is the element which is mainly responsible for video and audio compression system, applies to the digital transmission delivery system (terrestrial, cable and satellite, etc.) and benefits from common hardware and software which makes the construction of multi-delivery receiver easier and cheaper. Application-Specific Element is responsible for the modulators and demodulators for satellite and terrestrial television, digital television transmission is important due to its wireless nature in supporting mobile receivers, infinitely scalable architecture. Digital terrestrial television transmission is regarded as most important for the future of television broadcasting, and can be introduced in parallel with other means of delivery despite its lower capacity compared to Satellite and Cable television with larger channel bandwidth and frequency spectrum [5].

Performance Objectives of Digital Television Transmission

Signal quality is of outmost importance in digital television transmission, as such the average power within the transmission bandwidth is constant. The data representing video, chroma audio, data and sound are multiplexed into common digital stream due to random nature of the baseband signal. The digital system has a way of separately measuring aural and chroma carrier power levels and the average power varies according to the picture content. It measures quality in

terms of average power, peak to average power ratio, carrier-to-noise ratio, average energy per bit to noise density, symbol and segment error rates, bit error rate, error vector magnitude, eye pattern opening, inter-symbol interference and spectral growth. Linear distortions are evaluated and resolved swiftly [1]. The digital transmission system should ideally provide signals free of any impairment to all receiving locations within service area. Interferences in the system such as linear, nonlinear distortions and noise from the environment impair the signal and degrades the carrier -to-noise plus interference ratio (C/(N+1) (Gerald and Collins 2001:22). In overcoming the impairment in the digital signals, the coverage area of the receiving location is considered, the best receiving condition is achieved by moving the antenna up to 0.5 m in any direction. Transmission of digital signals involves the transmission systems, transmission requirements and standards which are planned for during network coverage planning to determine the strength, availability and reliability of signal reception at the receiving locations within the coverage area. When planning gets it right, impairments such as linear, nonlinear distortions and noise from the environment will not impair the signal at locations within the coverage area.

Placing a receiving antenna for DTV at some minimum height is a basic rule for good quality reception of DTV signals in all the modes of reception; indoor, portable and fixed. For digital signal reception there are no other techniques beyond designing network to satisfy preferred modes of reception and to obtain standard results. "A receiving location is regarded as covered if the level of the wanted signal is high enough to overcome noise and interference for a given percentage of the time" [5]. The main consideration when building DTT networks are the evaluation of service area and population covered in the context of required carrier -to-noise ratio and the protection ratio in analyzing the sensitivity of the system against interference [5]. The digital system requires frequency planning based on two main parameters of transmission necessary to meet quality target of signals delivered, namely minimum carrier-to-noise ratio C/Nmin and protection ratio PR. The C/Nmin indicates the level at which the carrier C must exceed the noise N level to achieve the intended quality, and the PR describes the level at which the carrier C must exceed an interfering signal to achieve the intended quality [5]. Ghana has a regulation on allowable combination of digital system modulation and transmission parameters on noise of 6.0 on all the DVB-T2 modes (mode 1-5, UHF, MHz, VHF and MFN) to receivers for the reception of signals (NCA, 2013). SDTV was chosen in Ghana because the analogue sets are in the majority of viewing households coupled with the fact that Set Top Boxes (STB) are of SDTV format, also taking into consideration cost reduction as the other formats require higher bandwidth. It is known that if the signal decreases and the carrier to noise ratio falls below the given minimum parameter of (6.0 in Ghana's' case), the pictures can disappear completely, which is referred to as "rapid failure characteristic of the digital system" [5].

Three methods may be used to determine transmission errors that occur in the digital system, namely segment error rate, bit error rate and symbol error rate. The segment error is the probability of an error in a data segment after forward error correction (FEC), bit error is the error before FEC and symbol error is before forward error correction (FEC). These measures are meant to check the robustness of the digital system and prevent data & signal loss. In planning Ghana digital broadcasting, a provision was made to make the network design scalable to ensure that future migration to higher formats such as HDTV will be possible without costly investment.

The quality of digital transmission system may also be expressed in Error Vector Magnitude EVM, considered the overall best method of measuring the performance of DTV, it considers all impairment that contribute to Intersymbol interference (ISI), the underlying cause of symbol and bit errors. Intersymbol Interference "is caused by any energy within one symbol time that would interfere with reception in another symbol time," [1]. Which in addition to noise results in dispersion within the channel being transmitted, linear distortion or timing error caused by band-limiting in the system. When the ISI becomes severe, the channel response smears and delays the transmitted signal causing the receiver to mistake the value of the transmitted symbol [1]. The ISI and C/N performance of the digital transmission system can be qualitatively assessed by using Eye Pattern. In transmitting signals, the overlapping waveforms produce a pattern that resembles the human eye. "the degree to which the eye open is a measure of the ISI and hence signal quality. The digital system ensures that the Eye open 100% correspond to an EVM of 0% for perfect transmission of signals. The digital system does interference analysis which originate from co-channel and adjacent channel stations. Co channel signals are signals from other markets which the digital television receiver detects as another type of noise. The adjacent channel signal is the signal from "another station or the result of third -or higher- intermodulation products generated in the power amplifier of other transmitters." To provide the desired carrier over noise ratio at the receiving area, it is important that the transmitter of the digital system produce a signal free of noise and of linear and nonlinear distortions at a sufficiently high power [1].

Methodology

Qualitative research design was adopted in this research. Qualitative research design was used in assessing the state of art technology of digital television transmission in Ghana through the usage of case study technique, and non-probabilistic sampling (purposive and snowballing) to obtain respondents and in-depth knowledge about the subject matter. This research adopts the methodology of multiple instrumental case study approach focusing on examining the state of art technology of digital television transmission in Ghana, and using KNet Limited to illustrate the issue.

Appropriateness of case study for the research

The 'case' of state of art technology in digital television transmission with respect to Ghana was identified and this research design seeks to provide in-depth understanding of the study; identified cases. Case Study and is made up Single instrumental and Collective case study which explores the research through one or more cases within the context of the study, it is a methodology which researches a case or multiple case through detailed, in-depth data collection through observations, interviews, documents and reports etc. and reports on the research [9]. The Case Study approach has been adopted in this research since it is a specialized area and knowledge on the study is limited.

Data Collection

Qualitative research data is expensive and time consuming to obtain as such a small sample size of 5 respondents obtained through purposeful sampling and 10 respondents obtained through snowballing were interviewed (conversational and discursive) through the usage of structured questionnaires in a fairly informal setting to obtain in depth knowledge about the study. Interviews were employed using structured questionnaires to guide the researchers in their data collection.

Data analysis

There are numerous ways of analyzing qualitative data namely coding, memo writing, outcroppings, ideal type, successive approximation and illustrative method etc. [10]. The ideal type by Max Weber is the qualitative data analysis approach adopted in this research is made of two types; contrast context and analogy and is an artificial device for qualitative data analysis because no reality ever fits the ideal type. Contrast context; adopts epistemological interpretive approach and is used to interpret data sensitive to context, it is not based on hypothesis or generalizable theory but brings out the specifics of the research to emphasize the impact of the findings. "*Above all contrasts are drawn between or among individual cases with the aid of references to broad themes orienting questions (framework for pointing out differences among cases concepts) or ideal type concept (benchmark against which to establish the particular feature of each case,"* which is applied in this research [11]. The usage of ideal type - Contrast Context in analyzing research data provides benchmark against which to measure digital television transmission in Ghana and technical specifications contract with KNet Limited.

Population and qualitative sampling

A representative non-probabilistic sample was selected for interview and examined for inference into the larger population. In using the non-probabilistic sampling, the sample size was not determined in advance since there is limited knowledge about the population, but gradually selected respondents relevant to the research in an ongoing process [11]. Purposive/judgmental sampling and snowball sampling were the sampling techniques adopted in this research KNet limited has been identified as most promising and useful case in this research, other purposefully sampled case includes Ministry of Communications, National Communications Authority, National Media Commission and Broadcasters provided different perspectives on the research.

Findings and Discussion

Digital terrestrial television infrastructure

Data was collected on: the technology used in executing and installing digital television transmission in Ghana (DVB-T2, MPEG-4, single frequency network, network architecture- central headend and transmission network, IP/ MPLS technology, Fiber Optics regional and local insertion of content from headend, parallel running of terrestrial and satellite platforms etc.); implementation requirement (fixed rooftop coverage, availability of affordable of digital receivers and set-top boxes; migration from analogue to digital receivers and availability of SDTV, SDTV on the same multiplex etc.); basic components of DTT in Ghana (single frequency network, headend and distribution over satellite), regulations for effective deployment of DTT (Electronic Communication Act, Broadcasting Act and DTT Policy etc.); impact of infrastructure sharing on deployment (reduced transmission cost and environmental sanity etc.). The data gathered on the digital television transmission revealed that all the technical infrastructural requirement of Ghana DTT in relation to the contract and ITU requirement have been met, however the effectiveness and efficiency of the installation cannot be verified because of the single frequency model of Ghana infrastructure and all the transmission sites have not been switched on. Ghana digital television infrastructure is to be operated form 42 transmission sites however at the time of undertaking this research, only two sites have been switched on due to:

Delay in Payment of Mobilization Fee, **t**he Government of Ghana through the Ministry of Communications was supposed to make an advance payment of 5% of the contract sum to the supplier-KNet being mobilization fee for the commencement of the project (DTT Contract, 2015) the payment however delayed significantly resulting in the commencement of the project in the last quarter of 2015 even though the contract was signed in July 2015, which resulted in the delay completion of the DTT Sites.

Delay in Construction and Completion of DTT Sites, Ghana digital terrestrial television platform is supposed to powered from 42 transmission sites (*Appendix III)*, however the contract awarded required the supplier -KNet Limited to build only seven (7) new digital terrestrial transmission sites and build the remaining thirty-five (35) sites using Ghana Broadcasting Corporation analogue transmission sites. The sites assessment by the supplier revealed that nine (9) of the GBC analogue transmission sites were in deplorables, as such those transmission sites had to be built from scratch i.e. sixteen 16 new sites were built in total. The DTT contract also excluded the building of transmission rooms placing reliance on existing analogue transmission rooms at the GBC sites which turned out being in bad state, the supplier therefore had to build 42 transmission rooms. All these DTT infrastructural revisions and its associated cost overruns resulted in the delay in completion of the project. Powering of transmission sites and project infrastructural changes also contributed to the delay.

Powering of the transmission sites, the digital terrestrial transmission sites have a high electricity consumption rate which cannot be economically powered with generator sets. The provision of electricity to the sites therefore rests on Electricity Corporation of Ghana (ECG) who at the time this research, are in negotiations with the Government on providing power to the transmission sites. All 42 sites at the time of this research had been completed, but (40) sites had not been switched-on due lack of electricity.

Other Infrastructural Changes, such as microwave/fibre link feeds (for connection/linking of television stations to the head end) and monitoring system which were hitherto not in the contract, had to be installed during the execution of the project resulting delay in completion and associated cost overruns.

Digital terrestrial television transmission: Digital terrestrial television transmission is supposed to benefit Ghana in terms of, higher spectrum efficiency, better picture quality, clearer sound, more stations for choice and infrastructure sharing etc. by 17 June 2015 per ITU Geneva 2006 Agreement, but was not achieved (DTT Contract, 2015). Data on DTT transmission was gathered on: Ghana reasons for choosing DTT transmission apart from ITU requirement (less storage and transmission space, superior video and audio quality, less signal deterioration on duplication, optimal utilisation of transmission infrastructure and enhanced services); impact of DTT on television viewing (better quality and improved viewing experience etc.); Ghana Simulcast Plan (shorter simulcast); effect of DTT on competition in Ghana Media Industry (reduction in market share of television stations, increase in market share of television stations with quality content etc.); infrastructure sharing (reduced cost of transmission); broadcasters perspective about digital terrestrial television transmission; effect of DTT on Broadcasters operational cost and Broadcasters transmission experience under DTT. The data obtained revealed:

Ghana reason for going DTT: Apart from the ITU GE06 agreement, Ghana is transitioning to harness the full potential of DTT and to avoid signal interruptions from countries that have transitioned.

Delay in DTT transmission: Ghana DTT platform is not fully operational so broadcasters, and all other stakeholders have not entirely benefited from the transmission of digital terrestrial signal.

Simulcast plan: Ghana will operate a shorter simulcast plan (one-year dual illumination) effective from the date of switching on all DTT sites, after which all the analogue television transmission sites would be switched off.

Broadcasters perspective about DTT: Broadcasters expect DTT to have increased bandwidth to accommodate more television channel as compared to the current limited capacity for only 40 channels, deliver attractive low cost multichannel services, provide HD and Ultra HD services since modern television studios and transmission chain are in Ultra HD. These could not be fully assessed since DTT is not fully operational.

According to Stump (2000), delay is referred to as an event or action that results in the extension of time required to perform tasks as specified within a contract, whilst Project financing involves raising funds in terms of debt and or equity to finance an economically separable investment project which is expected to provide returns for the servicing of debt and returns on equity [11]. Project delays are caused by many factors such as poor project management, poor planning and scheduling of project by contractor and suspension of project by owner etc. [12]. however analysis of the delay in Ghana DTT infrastructure supply and installation revealed the project was financially constrained. Ghana was required to transition to Digital Terrestrial Broadcasting in the bands 174 – 230 MHz and 470 – 862MHz by June 17, 2015 in recognition to its Geneva 2006 (GE06) (DTT Contract, 2015) (ITU Handbook, 2016) which has passed. The delay could be attributed to government failure to make timely payment of mobilization fee for the commencement of the project due to financial constraints. Project financing involves parties to the contract, reaching a financially responsible agreement to make the necessary funds available for the timely completion of the project [11]. The Government of Ghana per the (DTT Contract, 2015) document agreed to pay a mobilization fee of 5% for the commencement of the project which delayed significant, rippling into the delay in completion of the entire project [12-17].

Conclusion and Recommendation

Financial constraints and delay in completion of DTT infrastructure, Star Times Limited was awarded the contract for supply and installation of DTT network solution in 2012 who delayed for three years without commencing the project due to its inability to generate funds to commence the project and was cancelled in 2015, after which the contract was awarded to KNet Limited in 2015 which also delayed due to the inability of Government of Ghana to make timely payment of mobilization fee for the commencement of the project, which resulted in the project not meeting the completion date of February 2016.

According to Sweis et al. project variation results in time and cost overruns which affects the financial performance of the contract. DTT contract variations in relation to construction of 42 transmission shelters, 9 additional masts, and contribution feed etc. resulted in a huge time and cost overruns affecting the timely completion of the project; powering of transmission sites, power consumption of digital transmitters is relatively lower compared to analogue transmitters, however at the time study only 2 of the 42 sites have been powered although all the infrastructural requirement had been completed. The basic error being that the provision of electricity to the 42 sites and the Head end was not included in the DTT contract with KNET but left to the Ministry of Communications. If the provision of transformers and electrification were added to KNET, all sites would have been powered within the same period and much earlier because KNET would have had to deliver in good time in order to receive final payment. Even though DTT power consumption is low, the budgeted cost involved in powering the 42 sites is high since all will bear by the Government of Ghana, compared to the analogue transition where the transmitters are owned and powered by individual channels/broadcasters. The Government of Ghana was in a consultative meeting and negotiations with Electricity Company of Ghana (ECG) to provide power to the remaining 40 sites, which has delayed the transition of Ghana to the digital platform.

Most capital project involves high financial outlays, as such effective and efficient plan is needed in designing project contracts, and the DTT contract not an exception. Variations in capital projects are expected during the execution of the projects however with adequate planning it can be minimized to the barest minimum, the DTT contract excluded the building of transmission shelters, additional masts, and contribution etc. however these had to be built during the execution of the contract since it is necessary for the proper functioning of the DTT platform which came at an additional cost and resulted in time overrun. The contract was designed and awarded on the premise that the DTT platform will be built on existing GBC analogue site, which was not the case upon commencement of the project. There is the need for situation analysis, site and technical review etc. involving professionals, and evaluation of best from countries that have transitioned in planning projects of such capital nature to ensure that variations are minimized to meet the projected time and cost. Field data obtained revealed that some of the transmission sites were completed more one year ago but had not been powered at time of the study which makes the sites susceptible to weather conditions etc. indicating some may be in bad state, it is therefore recommended that all 40 sites yet to be powered are technically reviewed and maintained to ensure that they are in a technically acceptable condition before power runs through. there is the need to power the DDT sites in the shortest possible time since any further delays may cause technical challenge, though it is widely known that the power consumption of DTT platform is lower compared to analogue platform, the cost burden of powering these sites will be high on the government since it will bare all the energy cost alone. It is advised that the government concludes its negotiations with ECG and power the 40 sites as soon as possible, whilst exploring alternative forms of energy such as installation of high grade solar panels and invertors at all the sites to ensure continued energy supply and avoid unnecessary power cuts as witnessed from Ghana national grid, since the cost of power is reaching 60% operational expenditure and the cost of running generators on diesel as an alternative is almost three times the cost of electricity from the national grid.

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