Africa on the Way to Global Wireless Digital Television

Tristan Daladier Engouang, Liu Yun

Abstract*— The African governments and the United Nations' project of enabling full access to information and communication technology (ICTs) to all citizens, is of the most ambitious in Africa. Thanks to advancements in the broadcasting technology, the resulting digital television has led to transform the viewer experience, offering images with far better improved resolution and quality, whereas the sound is of the best quality. From the huge data consumption in mobile telephony causing the scarcity of frequency spectrum, the International telecommunication union (ITU), required from every countries worldwide to migrate from analog to digital signal, which become mandatory because, as of today, only the techniques used in digital broadcasting are spectrum efficient, what means requiring less spectrum for the transmission of a television signal of a very higher quality, explaining why a huge parts of that spectrum is been freed up for the benefit of multiple other services such as fire, education, emergency, governments, security. The trend as on the buzz in Africa became about switching over, but because, newest television equipments requires investing enormous funds, African countries are expecting foreign companies to operate in the digital television market expanding in the whole continent. In addition to the shortest time left to meet the deadline set on June 17th, 2015 by ITU, of just two years from now, when considering that as of may 17th, 2013, number of African have not started migrating their television system from analog to digital, what explain at this stage the latency and which, is as risky as it could led Africa to rush, avoiding to fulfill proper studies, in term of coverage, and market pricing. Analyzing properly the African situation, where choosing the wireless television including Satellite and terrestrial, over the cable television appears to be wiser. Moreover, it is worth that the transition started in 2008, in Rwanda, with the opening of the Chinese company Startimes' subsidiary, after receiving the first terrestrial digital TV operating license for pay television services.

***Index Terms*—Digital Television, Africa, Switchover, Satellite, Terrestrial, ICT, ITU.**

I. INTRODUCTION

The advancements in the broadcasting industry with the Digital Television (DTV) as a major result, has transformed the audience viewing experience, as enabling digital television operators (DTVO) to broadcast their contents with a very high image quality, best sound quality, and multiple programs with rich contents in multiple channels, what compels the human goals of the best picture viewing [1], The authors considered what is argued about the used of the information technology, being the only factor to meet the requirement of the world standard [2], providing access to information and communications technologies (ITCs) to everyone worldwide, is one of the united nation's millennium development goals [3], what is why African governments are working together to meet that challenge for their populations, and this explaining why during the opening ceremony of the 13th edition of the Forum on Telecommunication/ICT Regulation and Partnership in Africa (FTRA-2012) [4], [5], the Gabonese primer, as a chairman argued that "it is a common goal of African States to challenge the generalization of the digital economy and the Forum on Telecommunication/ICT Regulation and Partnership in Africa, being not only a source of hope for countries or populations of which, significant fraction is still excluded from the benefits of the information society, but the determination of our states to catch up'' [5], [6]. Because of the scarcity of frequency spectrum, the International Telecommunication Union (ITU) decided to stop all the analogue broadcasts on June 17th, 2015 [7], so that every country had to migrate from the analogue to the digital (Switchover), but a major attenuation on 34 countries was made including 30 sub-Saharan countries and 4 middle East [8], with an extension of five more years postponing the switchover deadline on June 17th, 2020 on frequency band III: 174-230 MHz (VHF) as shown in figure 1, all resulting from the Geneva 2006 agreement, of which most of African countries are mandatory, and where Africa ITU member states grouped in regions are reporting as explain in [5], to regional office as shown in table 1. Thanks to the digitization of television, the spectrum scarcity issue due to huge mobile communications' impact [9], is been solved and opening new rooms for much more services such as fire, education, emergency, governments, security [5], [7], [10]. That is why a number of Digital Television Operators (DTVO), including new competitors are all rushing to enter the Africa market, in order to remake the mobile telephone experience [7]. Because there is a huge profit to make, and considering the requirement of advanced technology and the high investments fund, the paper entitled "Africa the New Arena of Digital Television" [7], characterizing these DTVO as Gladiators engaged in a fierce fight with no concession to make [5], where Africa is the Arena and main competitors been the European Canal+ [11], the African DStv [12], and the Asian Startimes [13].

In addition, the advancement in broadcasting is making possible the new viewing experience which is about, the best high quality images and especially very good quality of sound [5]; And a simulcast period started in Rwanda, Kigali in 2008, and which is supposed to last until 2020, as shown in figure 2, at the time the extension will end, and this, when considering the fact that in Africa, accessing to Canal+ content or to DStv programs was only for a privileged class as everyone could not afford their respective parabolic antenna due to their elevated prices, and the trend now is in the opposite, as the new opening market, with more competitors is benefiting the population firstly in reducing the cost of the technology so that every single citizen in Africa could afford to own a set to box to view the digital television content, or just own any possible digital television offering device, based on everyone's income,

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compelling the status of Africa entered in the information age that was defined in the Era of Television Digital Africa Live (E-TDAL) [5].

This paper mainly highlights the global wireless digital television in Africa and how the switchover is handled by African countries with a finite choice in the wireless transmission of digital contents and also most challenges, when assuming that the implementation is been decided, especially how this new technology affects peoples in their daily lives, keeping in mind that, DTVO's invests are aim to make profits as the wide and open African market appears juicy [7]. And also in this paper, the literature is reviewed for the origin of our study in chapter 1, followed by chapter 2, that depict the real problem of the global trend of digital television becoming mandatory due to the scarcity of frequency spectrum at first glance.

Then chapter 3 introduces, the Africa global digital wireless television, that is in this paper limited to Satellite and terrestrial that are both wireless communication and chapter 4, discuss aspects aiming to clarify the reality on the question of implementing the digital television in Africa, making the difference between the lucrative aspect that most digital television operators a investing for and the social objectives shared by Africa government and the United Nations, of providing full access to ICTs to all Africa citizen, then chapter 5, will concluded this paper.

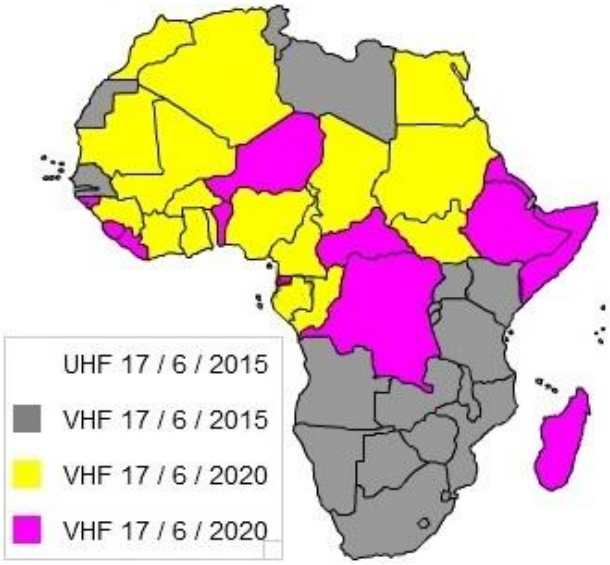

Fig 1. Extension referencing of African countries, each color represents the countries concerned by the specified deadline of the three frequency bands.

Table 1. ITU Member States reporting table.

Regions	Reporting office	Country
Central Africa	Yaoundé	Cameroon
East Africa	Addis Ababa	Ethiopia
Northern Africa	Cairo	Egypt
Southern Africa	Harare	Zimbabwe
Western Africa	Dakar	Senegal

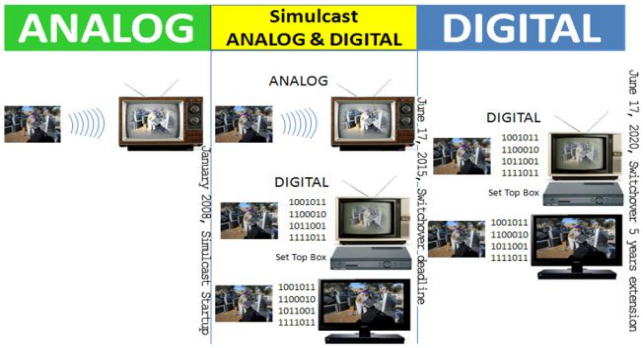

Fig 2. Simulcast period of analog and digital television broadcast, starting the switchover in Rwanda b

II. DIGITAL TELEVISION IS MANDATORY

A. The Standard of Television

All different from one another due to encryptions and securities measures, the international standards are well known to be incompatible with each others, which means that, the broadcasts from one of these standards, cannot be received by a different standards-based set top box, which Set Top Box appears necessary to be used as the channel tuner and especially provided by a specific DTVO, and these standards discussed in [5] as coexisting on the market are listed bellow:

- The Chinese DMB-T/H (DTMB):
- The North America ATSC
- The European DVB-T2
- The Japanese ISDB-T

Moreover, it is worth that the second generation of the European digital video Broadcast (DVB-T2) is the choice of most African countries. For in-depth details on above listed standards, please refer to [14].

B. The Cable Television

Thanks to John Walson and Margaret Walson in the spring of 1948 [15], with their Service Electric Company in the mid 1940s to sell, install, and repair general electric appliances in the Mahanoy City, in the mountains of Pennsylvania area started the Cable television, known in 1948 as Community Antenna Television or CATV [16], [17].

In addition, the cable television is defined in [17], as a system of distributing television programs transmitted through coaxial cables to subscribers via radio frequency (RF) signals or light pulses through fiber-optic cables, using a network of cables aiming to the delivery of multiple video, data, and audio channels, where any type of cable-ready television could be connected directly to its specific cable type outlet to be able to access the content instantaneously. But this is limited to the television types that are not cable-ready, and there are a lot of services provided through cables, such as the telephone service, the high-speed Internet and FM radio programming.

C. The Satellite Television

The satellite television provides a wide range of channels and services, often to areas that are not served by terrestrial providers, all over the world [18], it is a television programming delivered by all means of communications satellite,

where it can also be received by satellite dish or a parabolic outdoor antenna, as well as by an external set-top box or a satellite tuner module built into a TV set. In addition, the first satellite television signal was relayed from Europe to the Telstar satellite over North America in 1962, whereas, the world's first commercial communication satellite, called Intelsat I was launched into synchronous orbit on April 6, 1965. Since then it has evolve as of today with Eutelsat [19] offering a plenitude choice of satellite to the world but its 10A, is specific to Africa, and also the pan-African satellite RASCOM-QAF 1 [20] which is said to be in the shadow of Eutelsat satellites services as the digital television operators indeed prefers Eutelsat to Rascom-QAF1.

D. The Wireless Television

We defined the wireless television in this paper as of the traditional broadcast or terrestrial television that consisted of a television signal transmitted over the air by radio waves and received by a television antenna attached to a set top box or directly to the television, with multiple possibilities lately including Indoors, outdoor and mobile. In addition, it is worth to point out that, the television broadcast has been a lucrative business with pay television, in Asia (China, Japan, Korea),in Europe (England, France, Germany), in North America (United States) where John Walson was the first cable operator to distribute pay television programming (HBO), and in Africa (South Africa only). But with the switchover, becoming mandatory worldwide, the expansion of the television market in the whole Africa continent giving more opportunities to digital television operator's Pay TV services.

Moreover, In the paper entitled, "Television History: Television history was not overnight and not invented by a single inventor", and authored by Mary Bellis [15], the author argued that the Television was not a single inventor's hard labor, but many individualities working over the years on the same goal of the evolution of television. And describing its history as of two distinct paths of technology including a mechanical television system based on the technology of Paul Nipkow's rotating disks and an electronic television system using a cathode ray tube invented in 1897 by the Nobel laureate in physics Ferdinand Braun (1850- 1918) [5], then developed independently in 1907 by English inventor A.A. Campbell-Swinton and Russian scientist Boris Rosing [15]. Hence, let one be aware that Electronic television systems worked better and eventually replaced mechanical systems, and what changes followed until in the recent years with Braun's CRT been replaced by flat screen technologies including:

- Light Emitting Diode (LED)
- Liquid crystal Display (LCD)
- Plasma Display on Television sets.

III. AFRICA GLOBAL WIRELESS DIGITAL TELEVISION

A. The characteristics of the television images

The signals are known to be in the analogue of a periodic waveform in nature [21], and defined by their key parameters that are the amplitude, the phase and the frequency, which ones can be modified accordingly to obtain the modulated signals, that is why [5] argued that, the digital broadcast television system can greatly improve the spectrum efficiency for more channels thus more programs, which explains it superiority compare to the analogue, where one channel is equal to one program. In fact, the increasing number of available channels is obvious, thanks to the new techniques in the broadcasting such the digitization that decreases the bandwidth utilization of (Δf=2fm=8MHz, and fm=fc ± 4Mhz), per channel offering very high quality video and audio data, by the extremely basic elementary school algorithm (of Base 10), with the total number of programs in the UHF (474 MHz to 862 MHz) for digital television where the Standard definition television (SDTV) mostly shown with a 16:9 aspect ratio, which the latest encoding progress (MPEG4) can be as lower as to 1.2 Mpbs , a modulation based on DVB-T2 with allowing a data rate of about 2.8 Mbps, as the capacity of the DVB-T2 compared to DVB-T can be expressed in the following formula:

$$\text{Capacity} = \text{DVB-T} + [20\% \text{ to } 35\%] \qquad (1)$$

Hence the average number of channels and programs to available is equal to:

$$N_C = \frac{(f_M - f_M)}{8} = \frac{(866 - 470)}{8} \approx 49 \text{ channels} \qquad (2)$$

$$N_{Pc} = \frac{D_r}{D_c} = \frac{26.8}{1.2} \approx 22 \text{ programs per channel} \qquad (3)$$

$$N_P = N_c \times N_{Pc} \approx 49 \times 22 \approx 1078 \text{ program in UHF} \qquad (4)$$

Where,
f_M is the maximal Upper cutoff side frequency of the bandwidth
f_m is the minimal Lower cutoff side frequency of the bandwidth
f_o is the center frequency of the bandwidth
N_C is the number of channels of $\Delta f = 8$MHz
N_{pc} is the number of programs per channels
D_r is the data modulation rate
D_c is the data encoding value
N_P is the total number of program in UHF

In addition, it is worth to remind that all current TV standards in use today are derived from the black and white [22], but now with this profound and amazing transition of conventional television to the new era of digital technology, as analogue is to disappear for the benefit of digital, the black-&-white television is disappearing for the color TV, in which, the picture is represented by brightness of three principal colors (red, green, blue) as function of time, represented in form Ir (x,y,t), Ig (x,y,t), Ib (x,y,t) and that is why proakis et al. defined the color television picture as a three-channel, three dimensional signal simply referred to, as a signal that can be represented by the matrix of vector [21]:

$$\begin{bmatrix} I_r(x,y,t) \\ I_g(x,y,t) \\ I_b(x,y,t) \end{bmatrix}$$

Moreover, considering the actual advancement in the technologies and industry, we are tempted to predict that the three dimension television 3D TV, in the near future, will overtake, the simple colour television, the 1904 German patent, authorized by the FCC as the first commercial broadcasting on December 17, 1953 [15].

B. The communication relation between Signal transmitter and receiver

When The basic relation between a signal transmitter and a signal receiver and antenna could be resumed, as based on sightseeing relation or a direct line of sight (LOS) path, meaning that you cover what you see, based on the location and position of both antennas with respect to the obstacles placed around them [23], and just like it's sounds, the signal propagation works like the earth live day and night, where the sun will cover only half part of the globe at a time, and also three different scenarios have been studied in [23] as follow:

- Both antennas, receivers and transmitter, are placed above the tops of obstacles levels (above the rooftop level). This is call been in direct visibility or LOS conditions
- One of the Antennas is higher than the obstacle's height (roof), but the second is lower. What means that one or both antennas are in clutter.
- Both antennas are below the top of the obstacles. What means that both antennas are in obstructive condition

In addition, the profile of the terrain surface is very im-portant to be clarified for proper configuration of the propagation models and especially, helping one to predict the signal attenuation [23], and because it may vary from flat ground surface, curved and smooth terrain, rough terrain, hilly terrain and mountain, this in different built-up areas such as rural areas, mixed residential areas, suburban areas, urban areas. Moreover, because we are talking about terrestrial, and assuming that the signal is propagating over a flat terrain, there is still a strong multi-path signal as of one direct path from the air and a second from the ground reflection path, where the angle of incidence, is equal to the angle of reflection; That is the two-ray model (or two-slop model) [23], illustrating the perfect reflector and good conductibility of the ground as shown in figure 3, and where more accurate prediction is given at a long distance r, between the receiver (hR)and transmitter (hT), antenna height, with the difference in the radio path of two waves expressed in (5), the maximum power received at distance r is predicted in (6), and the distance between a receiver and transmitter expressed by (7) as follow in [23]:

$$\Delta\varphi = \frac{4\pi h_R h_T}{\lambda * r} \qquad (5)$$

$$P_r(r) = \frac{P_t G_t G_r h_t^2 h_r^2}{r^4 L} \qquad (6)$$

$$r_b \approx \frac{4 h_R h_T}{\lambda} \qquad (7)$$

Where
$\Delta\varphi$ is the radio path difference of two waves
h_R is the receiver antenna height
h_T is the transmitter antenna height
P_r is the maximum power received at distance r
r_b is the distance between a receiver and transmitter

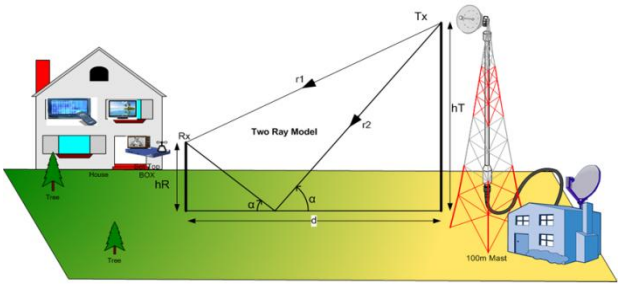

Fig 3. The ground, a perfect reflector in two ray model.

C. *Wireless Television as a must for Africa*

For Africa, the best or ideal digital television system is a whole combining only Terrestrial and Satellite broadcast TV system as shown in fig 4, where its limit is obvious, as it does not offer cable television services. Here there are four different types of incoming signals, from Satellite with Ku-band, and Satellite with C-band, from Radio frequency signals and a signal from the local studio, and after compression and encoding, the signal has to be modulate with Orthogonal frequency division multiplexing, (OFDM), prior to be sent to the broadcasting center for a broadcast in a wave form, and as well as to be transform by Quadrature Phase Shift Keying (QPSK) which is a phase modulation algorithm, prior to be sent to satellite via DVB-S2 uplink.

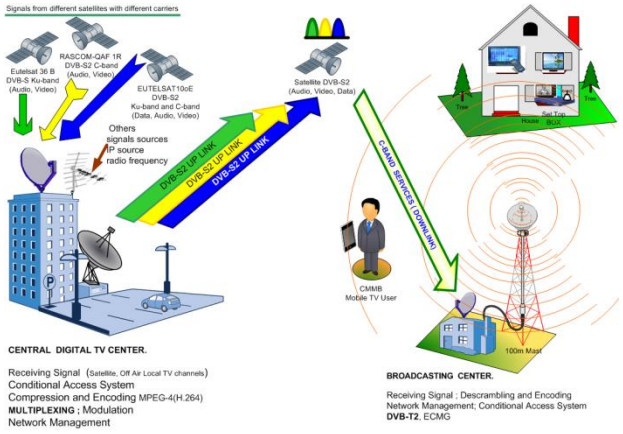

Fig 4. Ideal Digital Television System for Africa, combining only Satellite and terrestrial Signal Transmission.

The reality as a fact is that cable television, is more suitable for well urbanized areas such as residential constructions, colleges, compound, that is why it is mainly used in most developed country including China, since it was firstly introduced as of June 1948 by John walson in the USA, when connecting the mountain antennae to both his appliance store and several of his customers' homes that were located along the cable path, to starting the nation's first CATV system.

In addition, the cable requires much more investments and man force, to install and maintain over the years, also with all difficulties in Africa of logistic, telecommunications, transportation, including as well some villages with few houses of the suburban areas, far from cities that does not worth the investment. Thus, it appears obvious that the cable television is not supposed to be the choice of African nations, and here let us keep in mind that we are talking about the global population, because in some countries, or even in all, it still can be provided to some hotels, governments building, hospital, but only in big cities (for most cases, countries capitals). Moreover, because terrestrial and satellite are communicating wirelessly, one may understand, at this stage why it is wiser to invest and to deploy these two transmissions modes only, as for the terrestrial broadcast, the signal is just broadcast out in the air, for everyone so that they can enjoy its carried content, where the most situation will require a set top box, for indoors, or a digital TV set, and also for Pay TV, situation, a genuine pass in a smart card.

Hence, no further struggle in term of the maintenance at all, when all equipments are well configured. Furthermore, the satellite transmission mode is even better as in coverage area is wider and especially that it is the main link for international broadcast in the same country, but more importantly at intercontinental level, as it connect the Africa to all others continents thus to the world, what is, one of the main goals of the United Nations.

IV. DISCUSSION

A. The Digital television as a new challenge for Africa

From the global trend of the switchover and with the new ambitious goal of providing access to ITC to all Africa continent citizen, governments must face the liberalization of media issue, that gives lot of grievances to liberty of press when considering the changes with latest technology in broadcasting with direct to home satellite TV reaching 41 Africa countries by 2002, [24]. And the major accent point out the choice of the latest high technologies, for Africa millennium's project of Digital television on world first class technology leaders including Cisco, Conax, DELL, Eutelsat, IBM, Harmonic, Linux, Oracle, Thomson, with aim to renewing existing head end. But, reaching this goals, requires enormous fund to invest, which can explain the latency as of June 17, 2013, exactly two years from the switchover deadline, many African countries still have not starting the switchover operations of implementing the appropriate digital television system.

In addition, it is worth to remind that, transforming Africa and its partners' economies (both sides), is not about charity nor is it about aid, but all about investments and trades [25], also talking about the global development requires that everyone must make a lot of efforts [26], and when considering the fact that business opportunities have no restriction to anyone in Africa [27], where all investments especially in the ICT infrastructures that are is supposed to be advantageous for it shall create more jobs opportunities, also boosting considerably economic growth or income [28].

The reality is that with exception to northern Africa countries that have the technology and the capacity to invest in their own Digital television system, most African countries especially sub-Saharan countries, the migrating from analogue to digital depend on foreign or private investments funds, such as the example of some Eastern Africa countries, where the Chinese company Startimes (Star Media) [13], latest digital television operator to date, a valuable competitor to the French canal+ to the south African DStv that use to have a monopole respectively in French speaking countries and English speaking countries, which had started offering both digital television via set top box and mobile television kits to clients in many African countries where it is established since getting the first terrestrial digital TV operating license for pay television services in Rwanda [25], followed by opening officially of its first subsidiary Startimes Media (Rwanda) Com-pany], in 2008, thanks to the resolutions planning the multiple investments in Africa taken by the Forum on Africa-China Cooperation (FOCAC)'s, and also to the US $5 billion dollars provided by China-Africa Development Fund (CAD Fund), additioned to the Chinese CNY ¥ 2.5 billion loans from China Development Bank [29].

Moreover, with the sub-Saharan Africa countries' private foreign funds dependency, it might not be easy to implement the desired system on time, and more unfortunately, a proper study may not be available, as people will just rush to meet the defined switchover deadline, which we are tempted to say that some might not meet, because lacking enough time to fulfill, the advanced study required in the system basic design prior to go through the detail design that will lead to implementing the final system, Also, if the proper signal coverage is not closely study, one may find himself cut from the world, and we could even predict the inconveniencies to be caused, thus a simulcast period is definitely a must, as people should have the time to readjust, by changing their old conventional television into a new type that could be connect to audio and video cables from a newly affordable set top box.

Furthermore, the important decreasing prices in every single country, does not mean that every African will now be able to afford the technology, what remain a real challenge for governments to consider, is that for meeting the challenge of proving access to ICTs to everyone, is not just a fancy word, but requires a real commitment from governments that must provide a better content, to ameliorate the population life in every better ways possible. Hence we are tempted to say that Africa still has a very long way to go to accomplish the switchover goal to connect everyone to the world instantaneously. And the content is the most important thing to consider [30], by a DTVO, because the viewing audience (thus the resulting benefits) is determined by the interest to the contents that are offered in broadcasted programs from each of the multiple channels of the digital television. But when thinking about the liberty in developed country where some contents are provided freely, one should be ready to accepted to possibility of finding undesired contents such as adults' ones, also, If the DTV aims to educate the youth, movies channels or cartoons channels, that are broadcasting permanently 24h/7days, and others channels with content, from all types drama, actions, comics that could affect kids somehow, but the responsibility here, remain on their parents to ensure the control of what they are viewing. And, the television as part of ITC, bringing economic growth income as assumed in [28], the reality is that for African people, the primary need is still food as in most countries they are still starving also they are less interested in the television, and one could also consider the case of urban poverty in [31], and also to consider is the lack of electricity that most African sub regions are suffering of, meaning that to avoid a failure to the millennium goal of the information knowledge based on providing information and communication technologies (ICTs)'s universal access, governments, could consider play on the price of the technology and especially to create more jobs enabling people to be financially independent, as price is a very important factor, considering also that customers are willing to buy a product mostly for its benefits.

V. CONCLUSION

In this paper, we have discussed the global wireless digital television being implemented with trend of the global switchover and its impact in Africa, pointing out that the cable television is not suitable in Africa as its profitability is worthless to be invested for and also through a deep technical analysis and by all business means, an ideal Digital television system is introduced, it is combining only both satellite and terrestrial, and all are wireless communication based.

The paper discuss also most of the challenging issues that are specially socials, as the population has to fully benefit from the technology considering that that the benefits of a product are what motivates at most customers to be willing to buying it, but to reaching the goal of a global digital wireless television (GDWTV), can only append, with a total in-evolvement of each country's government. In addition that the latency in starting the migration from analog to digital is mainly due to the dependency on foreign funds, that only private investors such as the Chinese Startimes are providing as it is been the case in Rwanda (2008), Tanzania (2009) and Burundi (2010). People moving as countries are developing, we can assume that Africa still have a long way to go, so that the ambitious goal by the United Nations and African governments of providing full access to Information and communications to all citizen to be a reality and quality should matter at must to ensure people satisfaction, instead of quantity that aim, just to cover the biggest audience proving each one with a set top box of a random quality

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