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Evaluating The Sound Reinforcement Systems Of Gateway International Church Port Harcourt In A Digital Economy

Amaegbe, Esinkuma James Ph.D

Department of Music
University of Port Harcourt, Port Harcourt, Nigeria.
E-mail: James.amaegbe@uniport.edu.ng. Phone: +234 809 924 6494

ABSTRACT
The COVID-19 Pandemic which caused a serious pandemonium to the entire world seems to be fading away yet, has established a new normal in our societies. During the peak of the pandemic, a lot of Churches in the City of Port Harcourt were forced to shut down because of the COVID-19 restriction policies amongst which was the crowd avoidance policy established by both Federal and State Governments to help control the spread of the disease in Nigeria. However, a few churches in the city quickly switched to digital churching through mass and social media to reach out to their members and also establish a wider coverage of congregation. On this ground, it became eminently unavoidable, for the use of effective digital sound reinforcement systems such as an input transducer(microphone), to input sound into a processor (mixing console), which will process the sound, then sends for amplification(amplifier), to balance the sound before finally been heard from the output transducer (speakers) in a more subtle and efficient form. This processes enable live or pre-recorded sounds louder and capable to distribute same undisrupted massage to a larger and more distant congregation. Perhaps, musical and speech sounds could be reinforced more efficiently with two or more models of equipment such as amplifiers, speakers, sound mixers, equalisers, voice compressors and audio processors. Several research had been carried out on sound reinforcement systems and related areas in music technology to show how these sound reinforcements systems help music and speeches to meet both audience/congregation specifications. This paper takes off from this backdrop to evaluate the various sound reinforcement systems (SRS) deployed in Gateway International Church, to enabling live or pre-recorded productions thrive; arguing the need for using digital systems and platforms to achieving a new and sustained paradigm in music and speech pre and post productions. The researcher made use of onsite interview to gather secondary sources of data, to arriving at the position that Gateway International Church (GIC) Port Harcourt actually benefitted from this modifications/switch from analogue to digital sound reinforcements. This paper recommends that other users of sound reinforcement systems such as Schools, Clubs, and other churches need effective digital sound reinforcement systems to communicate efficiently and effectively with their broad spectrum of congregation.
Keywords: Congregation, digital economy, music technology, sound reinforcement systems

INTRODUCTION

Music technology in the 21st century incorporates the use of device, mechanism, machine, or tool such as computers and other high-tech musical instruments by musicians, composers, or other music assistants/personnel to help boost the quality of music and accompanying sounds. In an increasingly technological age where activities in the economy have gone digital, issues arising from sound management becomes very imperative in musical and speech activities. Thus, the use of sound reinforcement systems to enrich and boost the production of voices and musical instruments during

and after worship sessions, cannot be over emphasized. Musicians and sound engineers need to learn the effective use of sound amplification equipment and management of sound reinforcement systems such as the microphone, keyboard, stringed instruments, woodwind, brass, speakers, percussion and other instruments that require amplification during performance of orchestra and non-orchestra so as to attain audibility while interpreting the dynamics of the musicians instructed by the composer (Amaegbe, 2013). Sound determines the aim and tone of music and its patterns of reinforcement in any gathering which ~~is~~ significant to the achievement level of the entire performance.

Sound reinforcement provides amplification for a sound source, making sound audible to a large gathering of people. Schools, Clubs and Churches need good sound reinforcement systems; especially during gatherings that need to comprehend a larger population of people, for a smooth and uninterrupted sound production. Research has revealed that good sound reinforcement and management is very important in the control of sounds for the average noise rate for human consumption and wellbeing (Solomon & Olatunbosun, 2020).Thus, sound reinforcements can be done with the analogue or digital systems, or both simultaneously. The analogue sound reinforcement system consists of the form of technology that is used for recording and storing sound by creating a series of magnetic charges along a reel of magnetic tapes (Parasiz, 2018). Conversely, the digital sound reinforcement system is the form of technology used in recording and storing sound as a series of numeric values on a hard drive through a computer to effectively communicate to their audience or congregation (Elsele, 2021).Obviously, most schools, churches, and public places where sound reinforcements and management are relevant for good performance have been in the analogue system, and deserve upgrading to the digital sound systems in this present world of digitization.

Although this is true, but Atten (2011), believes that people mostly understand sound as a practical phenomenon, but do not understand the technical aspect of it, which is why they prefer the analog. To this effect, they feel that with the analog system, managing sound is easy. This means that once a musician or public speaker handles the microphone, he is expected to perform better, and have idea on everything that has to do with sound management such as sound reinforcement but fail to understand if the person has the ability or skills required to manage the reinforcement processes effectively in the analog system. When such persons apply sound reinforcement skills through haphazard, untutored, trial-and-error methods, and act as sound engineers/technicians at social functions, churches and concerts they do so at the risks of the appliances (Adebowale, 2008); thereby helping to promote sound reinforcement problems. Meanwhile, it has been observed that proper sound reinforcement systems management boost music and speech activities, yet it is often overlooked and seen as luxury by most users. A major impact of this, is that most times, the message and actual translations of the dynamics in a piece of music or speech is not properly communicated to the congregation due to poor and obsolete analog sound reinforcement systems.

Good sound produces all sorts of cognitive information related to mental processes of knowledge, reasoning, memory, perception, and judgment, but bad and unstable sound produces noise and discomfort (James, 2002).It is arguable that both analog and digital sound reinforcement systems can produce good sounds, but the processes of reinforcements are much different, as such may cause frustration and discomfort if not managed by experienced experts. However, the disturbances from the analog are most times inevitable no matter the skills of the technical crew because the reinforcements are done manually. But, where digital sound reinforcement systems are in use, issues such as hums, interference, feedback noise and unbalanced mix capable of causing distractions during performance can be overpowered or reduced to its minimal level, because of the application of automatic reinforcement systems programmed in the computer. This research therefore, sources the relevance of digital sound reinforcement systems in a contemporary digital era.

In view of the above, this work critically evaluates the benefits of digital sound reinforcement systems in Gateway International Church; what the Church did to get there, and how this can also be relevant to other users, especially churches.

Sound Reinforcement Systems (SRS)

Sound reinforcement is a process of using a technologically designed device such as computer or electromagnetic machines for the purpose of combining, routing, and changing the audio signal levels of sounds during and after performance. A sound reinforcement system or sound system is a device or compendium of devices used to manage sound production (Kimsher, 2023). It can be found in places

like halls, theatres, arenas, churches, schools, stadiums and other public places. A typical sound reinforcement system (SRS), is made up of the input transducers, signal processors, and output transducers. These sound reinforcement processes combine microphones, signal processors, and loudspeakers in enclosures, all controlled by a mixing console and or amplifier that makes live or pre-recorded sounds audible and clearer, and may also distribute these sounds to a larger or more distant audience/congregation on the same frequency (Elsele, 2016).

In the digital sound reinforcement process, each input signal has its own dedicated channel for audio distribution, and this channel is set to either stereo or monaural, depending on the type of audio distribution settings on the digital mixing console. This process may be in two major forms namely: the analogue and digital sound reinforcement systems; there is still a combination of the two systems which is the hybrid sound reinforcement system also called the 'digilogue' (Onwuegbuna, 2022).These forms of combination (hybrid),are being in use in most places where sound reinforcement systems are utilized, including churches. The Gateway International church is equally making use of a combination of high-tech analog and digital sound reinforcement systems. The formation of their hybrid sound reinforcement technologies is in no doubt very equipped for a proactive, integrative, and effective sound management and control approach.

The Analogue Sound Reinforcement Systems (ASRS)

In sound production, the analogue sound reinforcement systems (ASRS), is a representation of electrical signals by a continuously varying voltage (Loren, 1999). This form of sound production system allows musical or any sound to be stored in its original form, but as it passes through various processes, media and equipment of recording, it does that in the form of repetitive waveforms. Onwuegbuna (2022), opines that these waveforms called oscillators, they are always susceptible to distortions which are evidenced in timber, tempo, pitch, intensity, and overall fidelity of the sound signal at the point of playback the recorded sounds. He adds that the fidelity of the sound deprecates with each reproduction of musical/speech sounds into other media of storage.

The analogue technology supports the recording of the musical and or speech sounds in the now obsolete wax master disc, the multi-track reel, and the electromagnetic tape; which is also known as mechanical recording system (Moog, 2009). This system makes sound recording possible through the process of magnetization or mechanization. The magnetization process is equally good, and effective in sound reinforcements and management, and has been in use, and effective in sound management with modifications in its usage and applications over the years, but due to the contemporary trends in musical technology, magnetic processes are becoming obsolete. This paper thus describes the magnetization process to help us understand its support to the digitalization process.

Magnetization process

Salt (2009) stressed that the most connection method of sound recording is to use magnetic media such as tape to store the music, speech, or other sound being captured. However, by using this approach, sound waves are transformed through a microphone into electrical signals which are then used to magnetize a plastic recording tape coated with metal oxide. Besides, the magnetization process varies with the frequency and intensity of the sound being recorded; as such the tape which is usually in the audio cassette form carries a permanent record of the sounds that were picked up by the microphone (Atten, 2011). One major challenge of the analogue size is that as sound varies with time, some forms of mechanical movements in the recording medium are required to provide a sequenced record that reflects the sequence of the original sounds (Onwuegbuna, 2022). Thus, with the introduction of computer technology, with its initial roads into the entertainment sector via the synthesizer, spiked up a radical turning point in sound production. Therefore, this turning point eclipsed the analogue system of sound production, giving way to a more efficient, real-time, and almost seal-life digital system (Loko & Loko, 2008; Moog, 2009; Salt, 2009; Davis & Jones, 2000); helping to produce and manage sounds in a more subtle and high-tech processes. This is the end point where the magnetization process gave up for a more modified process; the digitalization processes in sound management.

The Digital Sound Reinforcement System (DSRS)

In sound production, the digital sound reinforcement system(DSRS), refers to an audio recording system in which the raw sounds emanating from the initial sources are represented by the spacing between pulses (bits rather than by waves as in the analogue) (Okanlanwon, 2002); thereby making the sounds less susceptible to degradation and interruption. The digital system uses computer programmes to manipulate the audio data stored in the form of alpha-numeric codes, which is done through mathematical processes (Fuerter, 2006; Stanley, 2005). According to Salt (2009), in the digital sound reinforcement system, many distortions are removed because the continuously varying sound signals are transformed into digital signals made up of a sequence of binary values, or a series of bits, by the process called quantizing or quantization, as soon as it captured. This process enables the stored sound to be checked and processed, so it can be practically reproduced just as it was recorded. However, the primary advantage of using the digital sound reinforcement systems is the ease of effectively processing, analysing, and manipulating of sound by an audio engineer or technical crew with the use of a computer (Nwamara, 2006). Besides, this flexibility provided by the digital system has made it a nearly stress endeavour to create sound effects, enhance sound quality, and ease the editing of the recorded sounds. The digitals sound reinforcement systems also help in eradicating the challenges brought about on time, space and adequate fund to run and sustain, maintain analogue sound systems for effective programmes.

The digital sound reinforcements still make use of the analogue technology as the input transducer (microphone) and the output transducer (loudspeakers) are mostly made in the analogue technology; though there are still digital transducers such as the Bluetooth (Engerbretson, 2007). However, the digital approach is more relevant to signal processing (mixing console) aided by a computer. In the digital sound reinforcement process, there are three basic elements involved in the creation of a sound file: the audio stream (the type of sound signal), the container (the type of file format that the sound samples are stored in), and the codec (the way the sounds are encoded into that format), (Stanley, 2005). These processes exist in both the analogue and digital sound reinforcement systems. Perhaps, the digital sound reinforcement system helps to eliminate all forms of analogue audio distractions and noise-related problems. Obviously, analogue sound system can still be useful even on the digital world, it only takes some processes to link it into the digital system; this process is what is called digitalization.

Digitalization process: Sen (2023), opines that it involves the appropriation of sound waveforms from their analogue sources, and transforming them into a sequence of numbers that is, the digital version of the waveforms. Fuerter (2006), asserts that in the digital sound production in acoustic material, acoustic signals are captured by the conventional microphone to produce an equivalent voltage function in turn is passed on to an analogue-to-digital conversion (ADC), which continuously samples its value to produce a regular series of numerical approximations. Thus, while digitalizing the analogue, the scratched sounds are further sampled; that is converted into computer language of alphabets and numbers, which are measured in intervals and voltages, and the outcome of the converted signals are written in programmes or music software that are then stored in CDs (Onwuegbuna, 2022).

Therefore, by interfacing this software which are wave samples of recorded sound patterns, with the synthesizers that are connected via the musical instrument digital interface (MIDI) to the computer system, it becomes possible to stimulate those analogue musical instruments and those of the African cultural ones to be digitalized (Mbanugo, 2006).

Analogue and digital sound reinforcement systems are used to transmit information such as audio and video, usually through electric signals. In digital technology, the translation of information is into binary format either 0 or 1, and these information are translated into electric pulses of varying amplitude in analogue systems before any sound can be produced.

Plate 1: Digital Sound Amplifiers

Plate 2: Digital Mixing Console

Plate 3: Digital Reinforcement Hanging Line array Speakers

Features of the Digital Sound Reinforcement Systems (SRS)

In order to further express the importance of moving into the digital technology in sound production and management, this paper showcased some key features of the digital sound reinforcement systems adopted by the Gateway International church, that give the DSRS more advantage in sound management in an era of advanced musical technology.

i. **Binary code:** The digital systems in the GIC use binary code which is a combination of 0 and 1, to represent information in the computer. It is easier to manage sound effectively with these codes.

ii. **Accuracy:** The digital systems in use in GIC produce more accurate recorded sounds than the analogue system because information is represented in a precise and consistent format, and programmed to withstand interference.

iii. **Processing speed:** The digital systems in use are capable of processing large amounts of data quickly and accurately to larger numbers of people, and to more distant places. The system are distant and global friendly; as members in their various locations receive same information in the same time.

iv. **Noise impunity:** The digital systems in use in GIC are highly immune to noise and unbalanced sound interference, implying that the transmitted information is less likely to be corrupted during performance. This has helped to improve the reinforcement behaviours of the church entirely in their services.

Similarities between Analogue and Digital Sound Reinforcement Systems

To be able to ascertain the common features found in the analog and digital sound reinforcement systems, it is very imperative to looking deeply into how both systems function. This will help us to make decisions on how to combine the sound reinforcement systems; comparing cost of purchase and maintenance. Some key similarities between them are;

i. The ASRS and DSRS can be used in processing and transmitting information.

ii. They can be used in a variety of applications such as audio, video, and telecommunications channels.

iii. The ASRS and DSRS can be combined with each other to achieve certain goals such as enhancing the analogue signals with the digital signal processor to produce a digital sound.

iv. The ASRS and DSRS require some levels of circuitry or hardware to function effectively.

Differences between the Analogue and Digital Sound Reinforcement Systems

Considering the use of a hybrid sound reinforcement system, it is necessary to evaluate the most visible differences between the analog and digital systems. This will help users to understand some reasons for the GIC to consider upgrading from the analog to a hybrid of digilog sound reinforcement systems. Hence, some major differences between the analogue and digital sound reinforcement systems were explained on the basis of the characteristics stated below;

a. **Signal:** The analogue SRS uses analogue signal which represent physical measurements, while the digital SRS uses digital signals which are a representation of discrete values and are generated by digital modulation.

b. **Waves:** The analogue SRS uses sine waves, while the digital SRS uses square waves, which produces more frequencies and allows for more easy transmission.

c. **Representation:** The analogue SRS uses continuous range of values to represent information, while the digital SRS uses discrete values to represent information, which makes information more audible and clearer.

d. **Technology:** The analogue SRS records waveforms the way they are, while the digital SRS samples analogue waveforms into a limited set of numbers and then record them in series of numeric values.

e. **Data transformation:** Analogue SRS is affected by noise during transmission and write/read cycle, while the digital SRS is noise immune during transmission and write/read cycle. Besides, unwanted sounds or disturbances can easily be edited during recording and storing.

f. **Response to noise:** The analogue SRS is more likely to get affected by noise, while the digital SRS is less likely to get affected during recording/production due to ease in editing.

g. **Flexibility:** In the analogue SRS hardware is not flexible, while in the digital SRS hardware is flexible.

h. Bandwidth: There is less band width in the analogue SRS while the digital SRS uses more band width to carry out same information.

i. Memory: The analogue SRS stores data in the form of wave signal while the digital SRS stores data in the form of binary bit.

j. Power consumption: The analogue SRS consumes large power, while the digital SRS consumes negligible power.

k. Application: The analogue SRS is best used for audio and video transmission while the digital SRS is best used for computing and digital electronics.

l. Cost: The analogue SRS has a low cost, while the digital SRS has a high cost of operation.

m. Maintenance: The analogue SRS is more difficult and expensive to maintain, while the digital SRS is less expensive and easy to maintain.

Factors Affecting Sound Reinforcement Systems

There are different ideas put forward by scholars, manufacturers and users of sound reinforcement systems to support its structure and effective use. These factors have been categorized under two major sub-themes namely: human and material factors. A critical consideration of these ideas can make a significant difference on issues of sound reinforcement and management.

1. Material-based factors: These are factors affecting sound reinforcements directly caused by the behaviours of the materials used in the building where the sound reinforcements are sourced from;

a. Acoustic behaviours of rooms: In the19th century, Felix Savart through an experiment discovered that the pitch of musical sound depends on the vibration of the vibrating substances such as wood, air, membrane, metal or reed (Mawusi, 2020). His theory states that the pitch of any sound depends on the number of frequencies of the vibrating substance per second; thus, that slow succeeding frequencies produce low pitch, while fast succeeding frequencies produce high pitch". Besides, it was further argued that audible sound cannot be produced without the vibration of the instrument or substance involved. Relatively, Hal-Leonard (1998), in Okanlawon (2002), stressed that sound by its nature can bounce to and fro in solids; thus, surfaces such as walls of a room can help bound sounds effectively, and if its reflection is not checked, it can lead to the sound responding based on the dimension of the room. Before the upgrading of the materials used in revamping the church auditorium, the church experienced very poor sound reinforcement processes, as musical sounds and speeches were interrupted by echoes.

Critically analysing the cause of this, it was found that when sound produced has the same length as the largest dimension of the room, it will be reflected back and forth from the opposite walls and arrive back either in phase or out of phase relative to the original sound, thereby causing echoes. But when the reflected sound is in phase with the original sound, the former will reinforce the intensity of the latter, resulting in undesirable high peaks in the final sound (Eargle & Foreman, 2010). This occurrence is known as "standing wave". Thus, when the reflected sound is out of phase, with the original sound, some sections of the original sound may be missing completely, thus, resulting in dip and some dead zones created in the final sound. The church was suffering from this situation because material based factors were not considered as factors to affect sound reinforcements during the building of the church.

However, this information is useful as a guide in determining how room dimensions can affect the fundamental frequency of an instrument played and also the behavioural patterns of such instruments in other typical environments. In order to understand how sound behaves in a given environment, it is necessary to consider first, some of those physical properties that can affect sound in a typical room (Marty, 2010). If the sound has been outdoors, we would be considering how environmental factors (temperature, wind, humidity, etc.) will affect sound. In this case, our point of study is indoors; which is sound reinforcements in Gateway International church. One very important thing that affects sound indoors amongst others is, the very nature of the room itself – how it is constructed, the materials used in its construction, the content in the room such as, ceiling, floor, furniture, windows, etc.

In addition to these, the law of conservation of energy plays an important role as regards acoustic energy when a wave energy strikes a surface or an object in a given room, some of its energy will be reflected, and converted into heart energy, or absorbed and the remainder will pass through to its destination. The magnitude of this energy that will be reflected or absorbed depends on the shape and the materials used to construct the incident surfaces of the room. This can be referred to as boundary

effect. Gateway International church while trying to improve her sound reinforcement management behaviours, have been able to over the years understand the behaviours of sounds inside the church, and have renovated the church with adequate utilization of acoustic materials to building the interiors of the church; from the floors, walls, down to the ceilings. These materials have helped to improve the reinforcements of sounds inside the church; thus, reducing the problems of humming, vibrations, echoes and other disturbances experienced during performances over the years.

Therefore, it is very important to note that different instruments have their characteristic frequency range and energy in the audio spectrum. The acoustic energy resulting from playing these instruments has to be controlled in one way or the other, if sound must be controlled effectively. Energy cannot simply be told to go away – says the law of conservation of energy; as such, it must be controlled to ensure that the sound heard when an instrument is played is desirable, whether it is being played in a hall or a rook especially if the sound is to be captured using microphones. Thus, one of the techniques used in the control of acoustic energy is known as acoustic treatment. Adekogbe (2019), stressed that acoustic treatment is very important in the reinforcements and management of sounds in the environments to the recommended average noise level adequate for human consumption and wellbeing. They revealed that the lack of appropriate acoustic treatment in churches, has led to severe sound reflections and echoes causing noise pollution and poor sound reinforcements, and health problems to church members and neighbours. They recommend that churches should adopt the utilization of good acoustic treatments in their auditorium to help manage loud and noisy sounds. Rudy (2008), outlines three established methods used by acoustic professionals to apply treatment to a room as follow: (i) reflecting; (ii) absorbing; and (iii) diffusing techniques.

Absorbers attenuate sound, diffusers uniformly distribute sound and reflectors re-route (or redirect) sounds. Perhaps, distinguishing is a special kind of reflector; a perfect reflector would reflect sound with no loss in energy, while a diffuser will attempt as much as possible to diffuse or scatter reflection uniformly; but with loss of energy.

In acoustic treatment, special materials were employed to reduce or attenuate undesirable standing waves and therefore preventing unnecessary ‘colouring” of natural sound. Special properties of sound wave which are skin to light waves are those that can be reflected, refracted and absorbed. The special materials mentioned above are collectively called acoustic materials, and were used for the acoustic treatment of the GIC for proper sound reinforcement and management.

b. Acoustic materials in use: Most of the materials used for acoustic treatment (sound absorption) and sound proofing (sound isolation) in Gateway International church included rock wool, glass-fibre, plaster board, flooring cupboard, roofing felt, mats, carpets, gaskets, timber wood, isolation board and so on. These acoustic materials are commercially available from shops and vendors across Nigeria. There are also other special acoustic materials or devices available that can either be used for trapping, isolating or be turned to resonate sound energy at specific frequencies. These materials are mostly ordered through specialist companies that deal on acoustic materials and treatment of buildings for sound management and control.

c. Absorbers: Some materials such as foams, heavy curtails, acoustic tiles and even carpet can satisfactorily absorb mid and high frequencies but not low frequencies. Therefore, the low frequencies (bass) must require specially constructed absorptive equipment to eliminate the undesirable long-standing wavelength characteristics of low frequency from being reflected. One of such equipment or device used is called an absorber (Hosken, 2020). There are two types of absorbers; the panel absorber and Mi-to-High frequency absorbers. The panel absorber is basically a bass trap device which is simply constructed, consisting of a wooden frame filled with glass fibre or rock wool to allow the absorption of low frequency energy. The GIC made use of these technologies to sound proof the reinforcement process in the equipment arena. While the mid-to-high absorber is the simplest and most common variation of a panel absorber, constructed from commercially available open-cell foam as used in furniture making and mattresses. This absorber was used to panel the arena where the church choir section is built to help absorb sound while reinforcing the desired ones. These refurbished church environments are now helping to absorb extra and unwanted sounds to keep the reinforcements ideal for human hearing and comprehension.

d. Resonators (Trap): Converse to panel absorbers, resonators “trap” have a significant proportion of a specific frequency band rather than absorbing it. They may be safely described as damped resonant structures that operate by converting sound energy to heat via frictional losses. An actively effective

bass trap or low frequency absorber can be designed to absorb the offending frequencies causing coloration problems while at the same time reflecting and diffusing the higher frequencies resulting at the end in a very natural, acoustically sounding environment for recording and mixing. Thus, the most common resonator is the Helmholltz resonator or absorber. Gateway International church is making use of this resonating technology to help trap the proportion of frequency band to its required sound. This process has also contributed immensely in the enhancement of sound reinforcement systems in the GIC.

e. Sound Proofing: In contrast to acoustic treatment, has a primary aim to achieve an even reverberation time; that is control of reverb delay time across the audio spectrum through absorption. Soundproofing deals solely with the isolation of sound. In other words, preventing sound from either entering or leaving a recording room; this is a better form of sound reinforcement. Isolation is a matter of the materials and techniques employed in the construction of such a room (Davis & Jones, 2000). Sound proofing is often put into consideration in situations where it is desirable to keep unwanted noise such as traffic, train, and plane, noisy activities from neighbouring companies, and other noise pollutants within the church environments entering into a recording room or preventing sound from getting out of the studio or church, to disturbing next door neighbours. Research has found that exposure to excessive sound volume is a major challenge to grapple with in church auditorium in South western Nigeria, which has become a source of noise pollution dangerous to human health (Solomon & Olatunbosun, 2020).They also revealed that most churches expose their members to the average noise level of 90.29dB (threshold of pain), at every church services, which is higher than the recommended 60dB for normal human health by the World Health Organization (WHO).

The issue of sound proofing cannot be overemphasized in Gateway International church, because the church has been very proactive on sound reinforcements and management. In the year 2016 when the Rivers state house of assembly carried on a bill on punishing churches promoting noise pollution through their sound reinforcement systems, Gateway International church by the same year 2016, became one of the first churches in Port Harcourt metropolis to venture into sound reinforcement and management in general. They worked on their sound management systems in order to reinforce good sounds in the church, built good sound protective systems in the church to soundproof sounds from the church, in order to avoid disturbing neighbours during church services, and to avoid noises polluted outside the church by neighbouring companies, workshops, and moving vehicles distracting worshippers. Thus, apart from the act of complying with the proposed law, the church was able to build a system that has improved its sound reinforcement processes to a very significant level that she enjoys the digital sound instruments presently used in the church, and their sound reinforcements at ease.

f. Type/level of the sound reinforcement systems in-use: Another major factor that affects the sound produced in a reinforcement process is the type/level of the SRS in-use. This may consist of the type and level of the input transducer in-use, the output transducer in-use, and the signal processors in-use. When there is no appropriate mixture or blend of equipment, it can actually affect the sounds produced (Elliot, 2016). If these equipment are not in good shapes due to lack of adequate maintenance, they can also produce bad and unbalanced sounds. The Gateway International church in compliance with sound control laws engaged the technical engineers in thorough research and development approach in order to have a comparative analysis of the best sound reinforcement systems in the present day music technology. This approach yielded a splendid and significant result as the technical engineers were exposed to more advance and advanced musical/sound reinforcements systems, whose specifications and costs were proposed to the church management for choice of brands, and advice. By the end of the tripartite (Church management, Technical engineers, and brand dealers) discussions, decision was reached to make use of the digital sound instruments presently used in Gateway International church for sound reinforcements and management. These systems have been effective; giving to the church what they expected in terms of sound reinforcements, and also meeting the trends of technology in the digital era.

2. Human-based Factors:

These are factors directly affected by the technical know-how of the sound engineers/technologists. From the research conducted on the human factors impacting on the GIC sound reinforcement systems, it was found that there was no earlier adequate technical knowledge of how the reinforcement environment of the church works, and of how the reinforcement systems work in the

church auditorium. Research has found that the sound engineer or technician need to have the ideal knowledge of sound reinforcement of a building; the materials it is made of, and how the systems work (Onwuegbuna, 2015). It is this information that will help the sound engineer to understand the acoustic behaviors of the building and how it works with the reinforcement equipment. Without this knowledge, it is difficult for a sound engineer to manage sound productions effectively to eliminate muddling and hums during performance without understanding the behavior of these two systems. The sound engineer therefore needs to know that sound energy has to be converted to be either retained in its original form or be persuaded to convert itself as much as possible to heat energy before it gets out of or into the walls of the church. As such, constructing an excellent church environment is often quite expensive as all walls; doors, ceiling and floor may have to be doubled, just like having a room within a room (Amaegbe, 2013). Since adequate sound isolation is practically impossible to achieve in a room or an environment that was initially designed or constructed for other purposes, a satisfactory and inexpensive isolation can be achieved by paying attention to the under listed criteria as pointed out by Harty (2006), thus, that -

> Sound leaks out through air ducts and electrical cable conduit holes, door edges, windows, air conditioners ducts, and so on; devices that can introduce noise into a finished sound-proofed room such as light fixtures (most especially florescent lights), air conditioner, refrigerator, overhead or standing fan, some alternating current (AC) to direct current (DC) adaptors may hum once voltage drops; self-induced problems – avoid direct attachment of sound sources to the walls, floors, or ceilings; use acoustically treated monitor speakers or have speakers mounted rigidly on special stools or stands. More than one layer of carpet can be used for suspect floors to absorb unwanted sounds.

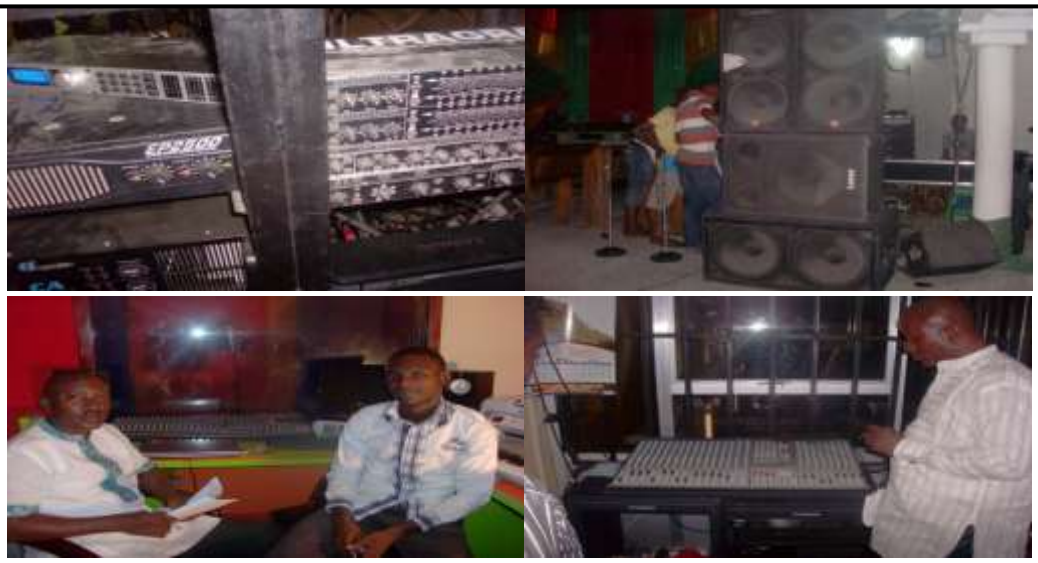
Consequently, it is also very important for the sound engineer to take into cognisance the following facts on the nature of sounds as stated by John (1993), thus that:

Sound travels well through solids; doubling of the mass of a wall can result roughly in halving the amount of the sound transmitted; anything done to isolated one solid section from the next helps to attenuate sound; and where acoustically absorbent materials are used, better results can be achieved by ensuring air tightness between partitions.

The above information has helped the GIC to enhance the acoustic behaviours of the church auditorium, thereby upgrading their choices of acoustic treatment appropriate for good sound reinforcement management and control. Thus, it is this information that the GIC sound engineer is still making use of in the control of sound diffraction and reflection if any erupts during and after services to keep recorded sounds in their original form.

GIC in the Analogue SRS

From 2013 backwards, the Gateway International Church was reinforcing its music and speeches with the analogue sound systems as informed by the then Church sound engineer Mr. Christian Peters. During an assessment of the church sound reinforcement systems with him, disclosed to the researcher that the input transducers such as the microphones, instruments (drums) and pickups the signals processors such as the pre-amplification channels, mixing console, effects, routes, crossover channels, and amplifier routes; and the output transducer such as loudspeakers, monitors, and headphones are still in the analogue system. He opened up that the analogue system actually has its advantages such as being accurate in the representation of sounds in its original form, audio being well stored/achieved once recorded, many classic analogue hardware processors such as EQs, compressors, etc; warm, rich and natural sound enjoyed by listeners, editing limitations which discourages constant tinkering/over-effect impact, has dynamic range with pleasant coloration, and also access to physical knobs, sliders, and stitches to shape/control the sound.



A View of Some Analogue Signal Processors in GIC

Besides, these benefits the sound engineer lamented that the analogue sound reinforcement system has its challenges which includes amongst others the high level of noise interference, expensive nature of tapes for sound recording, relatively difficult to get and vulnerable to deterioration, sound deterioration during copying, difficult in editing any section with errors (will require to cut off the tape to remove the problem before re-joining the tape, which may cause total wastage), sharing device is restricted and lacks portability, require regular maintenance, alignment and occasional demagnetizing for the systems to function properly. According to the sound engineer, the challenges which the church faces while using the analogue SRS outweighs its benefits, as the church incurs more money on the maintenance of the analogue SRS in order to keep them fit to give out the ideal sound which the sound engineer deems appropriate for music and speeches; yet cannot reach out to a wider coverage efficiently and effectively, and at same time.

In the course of facing these challenges in the church, came the era of Covid-19, where churches in Nigeria including those in Port Harcourt were forced to shutdown to help reduce the spread of the disease. According to one of the sound reinforcement crew members, "the Covid-19 restriction policy of crowd avoidance to help curtail and control the spread of the disease in Nigeria was an opportunity for the church to maximize in putting its sound reinforcements problems in place". The church engineer stressed that during this era proactive churches in Nigeria started switching over to digital churching to reach out to their members, and equally reinforce good sounds from distances beyond the normal church seating arrangements, the GIC also followed the trend. The GIC used the medium to acquire digital sound reinforcement systems capable of reinforcing sounds for a larger capacity of the church onsite and online, and in addition, increasing revenue generations for the church. The Choirmaster at the GIC disclosed to the researcher that presently the sound reinforcement unit of the church also manage their sound issues by caging the acoustic drum using the direct injection box (D.I), and the use of digital speaker management device to control sound from amplifiers to speakers.

The GIC targets not achieved using the Analogue SRS

The Gateway International Church had many targets set out to be achieved during the periods of the analogue system; unfortunately they couldn't due to the shortcomings in the analogue technology. Perhaps some of these targets were:

- having a global coverage of members within and outside Nigeria;
- having a sound reinforcement system that is void of noise and unbalanced mix; capable of causing distractions and diffractions;
- having an online presence and coverage to reach both members and non-members of the Church;
- generating more revenues from online coverage/services;

- Increasing the membership of the church through online services, amongst others.

GIC in the Digital Sound Reinforcement Systems

The Gateway International Church from January 2014 to date has made so much improvement in their sound reinforcement behavior towards joining the digital train, as disclosed by the head of musical unit of the church. From an aural discussion which the researcher had with Dr. Tamunosisi Mac-Pepple, one of the ministers in charge of music Unit in GIC, the Minister disclosed that the church has no issue with its sound reinforcement systems though only needs improvement in line with technological trends. He claims that the GIC is using the mixture of the two sound reinforcement systems – the analogue and digital (Hybrid) SRS, which he called the "Digilogue", because it processes analogue signals with digital equipment. In addition, the sound engineer at GIC Mr Christian Peters disclosed that it will be good to introduce the direct injection (D.I) box to help reduce hums and buzz problems; while combining the two sound reinforcement systems.

However, critically evaluating the sound reinforcement systems of the Gateway International Church in the last 10 years (2013-2023), when the researcher visited the church for an assessment of the church musical/sound equipment, it can be obviously recorded that the church has fully adopted the digital music technological systems to fit into the contemporary trends in digital economy, most visible in Churches. From the latest review on their equipment, the GIC is using both the analogue SRS and the digital SRS (hybrid SRS). The church although making use of the analogue SRS, but these sound systems are modernized ones that have little of digital signals in them, and they include the microphones and speakers.

Thus, the complete set of digital SRS acquired is a computer that controls all the signal processing applications such as preamps, mixer, equalizer, amplifier, crossover, effects, etc. However, the church has a control room with well-equipped hybrid/high-tech sound reinforcement systems, well-trained sound engineers, and other crews on sound maintenance, all working together as a team to reinforce sound during church services, and also reproduce recorded sounds during and after services.

The GIC targets achieved using the digital/hybrid SRS

This research found that the Gateway International Church benefited a lot while digitalizing its sound reinforcement systems. According to one of the sound crews, who requested to be anonymous, "the system is now very dynamic and has engaged lots of equipment to help the Church achieve its objectives". He further disclosed that the GIC has been able to create access to high-tech digital sound technologies for her sound reinforcement management, which was more feasible during the Covid-19 pandemic and became most viable in the post-Covid era. Some achievements of the GIC as revealed in this study are as follows;

Plate 4: Rebranded Church Auditorium with Acoustic Materials

Plate 5: Acquired brand new sets of high-tech digital equipment;

Plate 6: Constructed a Standard Modern Online transmission Room

Plate 7: Built-in a Wi-Fi System for an Online Presence

Plate 8: GIC Trained professional Production crew

Plate 9: GIC Digital Sound Console and Stage Light Soft Ware Console

The church now have an app (Gateway Connect) on Google play store to connect to their services and resources online.

Challenges faced by the GIC on the DSRS and HSRS in-use

It is actually not an easy task using the combination of the analogue and digital sound reinforcement systems in an organization; considering the cost of maintaining and sustaining just a form of technology. Sequel to this, it was found in the course of this research that, the GIC has been constrained with the following challenges while using digital and hybrid sound reinforcement systems simultaneously. Some of the challenges as disclosed by some of their sound crew are:

- **Poor power supply**: resulting to high cost of using petroleum products to operate electronic plants/generators. Unfortunately, there is inadequate supply of electricity in Nigeria; even when electrical supply is available from the national grid, the voltage is often either too high or too low, or not stable which could, and sometimes causes damage to electronic equipment. As a result of this, the GIC is forced to power their sound reinforcement systems with "stand-by generators", to help reduce the risk of damages; but alternatively incurring additional operating cost.
- **High subscription rate**: Another challenge to live sound reinforcement experiencing by the GIC in the use of the hybrid tech is high cost of subscription for online presence. The cost of building a Wi-Fi, and subscribing it to continuously be online, and actively enjoy the network due from service providers is very expensive in Nigeria. This situation makes the Church run into huge expenses to ensure global presence.
- **Consistent network problems**: Network problem has become a major challenge to online presence in the GIC. Most members complain of either poor network from the church network provider or their phone network provider. This ugly situation makes the church to sometimes not being visible online as at when due, or members not being able to connect as at when due.
- **Cost of employing or training sound engineers:** The cost of building a team of technical know-how/skilled professionals on digital sound engineering has been a very contemporary issue in the management of sound reinforcement, and its systems in the GIC. To avoid people who are half-baked sound engineers to work on trial and errors on the church equipment, the church needs well trained sound engineers. Thus, the need for training and re-training by

the side of the Church. Sometimes, after spending a lot to train these sound engineers, the experts leave the GIC to another church, leaving the GIC with the need for replacements; thereby making the training of experts a current liability.

CONCLUSION

This paper revealed that Gateway International Church Port Harcourt has improved tremendously from analogue to digital sound reinforcement; which was visible during the Covid-19 pandemic. This action brought a lot of benefits ranging from the production of good sounds, through larger coverage, more revenue generations, to more than 50% increase in its onsite and online membership. Although, these benefits have been found feasible, sound reinforcement remains one area of sound management where most churches and institutions are failing; not withstanding its significance. Perhaps, this calls for the need for immediate priority in improving and sustaining the quality of sound systems used in public places, especially churches. Many times the message and actual translation of a piece of music or speech is not felt by the congregation because of poor sound production. Despite the poor acoustic characteristics of churches, good digital sound reinforcement systems can assist musical performers/speech presenters in the establishment and maintenance of good sonic connection with their audience or congregations. However, live sound reinforcement should not be regarded, or employed as a substitute for adequate preparation and rehearsals towards successful performances. In a perfect system, a trained professional would always be available to purchase, setup, and operate the church sound systems. In reality, most institutions deem it not necessary to fund such, as they see it as luxury. Therefore, this paper recommends from the findings made on the GIC, that:

Churches and other sound reinforcement system users should consider rebranding at their pace, by employing the use of digital noise reduction devices and speaker management unit, to control their sound reinforcements.

Training and re-training of sound reinforcement personnel by a recognized sound engineer or sound reinforcement institution is very important to acquaint them on how to use and manage digital/hybrid sound systems effectively.

Users of sound reinforcement systems must imbibe a good and proactive maintenance culture to preserve their equipment.

All sound equipment purchases should be geared towards digitization.

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