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Effectiveness of Maintenance Policies for Cellular System Infrastructure Project

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Abstract : ***This study explores and proposes an effective maintenance policy to address, upgrade and ameliorate the problems of erratic and spontaneous breakdown of Global System for Mobile Communication (GSM) Cell Site transmission equipment. Survey technique through opinion research method was used to obtain primary data from the professionals and expert network providers and servicing companies. The instrument used for data collection and measurement was a well standardized questionnaire modeled in Likert- five point scale. Area and judgment sampling procedures were employed using South East and South-South political zones in the Niger Delta Region of Nigeria. The method of Multiple Comparison Test was used to analyse and assess the level of effectiveness on the existing maintenance policy options considered in the study. The result of the analysis establishes that there exists significant difference in the level of effectiveness of the maintenance policies. The predictive/condition-based maintenance policy ranks first and hence the most effective maintenance policy for abating excessive downtimes and, enhancement of quality and reliable network service delivery of the information system. The management of network service providers should therefore foster human capacity development in the area of predictive/condition based maintenance project management.***

Keywords: *Cellular System, maintenance policy, infrastructure project, predictive/condition-based maintenance, base transceiver station, Cell Site.*

1. INTRODUCTION

Maintenance encompasses all the activities that relate to keeping facilities and equipment in good working condition and making necessary repair when breakdowns occur, so that the system can perform as intended. Cell site equipment and facilities are subjects of maintenance due to incessant failure and breakdown resulting to frequent difficulties in information network service delivery and communication gap. The introduction of Global System for Mobile Communication (GSM) services was meant to cushion the excruciating experiences in communication, but they are being characterized by frequent erratic, unreliable and abysmal performance due to incessant breakdown of cell site transmission equipment and facilities. No robust and time effective maintenance policy is put in place to bring the equipment in good working conditions. Infrastructure projects such as telecommunication and power are capital intensive, multiple equipment-oriented works and involving large quantity of component parts and subassemblies. (Chandra 2006). They are usually designed by specialized engineering firms and consultants. In information system development, Cadle and Yeates (2008) observe another subtle feature of such projects as involving considerable complexity. Also, Agrawal and Zing (2006) opined that a cellular system requires a fairly complex infrastructure. Sharma (2006) succinctly put it that the description of a wireless network standard is a complex process that involves detailed specification of the terminal, fixed hardware backbone, and software databases that are required to support the operation of a cell site. It could be on these reasons that the cell site transmission equipment and facilities are vulnerable to incessant breakdown and without effective maintenance policy. Harsh weather conditions and aggressive operating environment could as well contribute to incessant breakdowns of the equipment. It could be that the maintenance policy on ground for this equipment is neither appropriate nor effective. There is need therefore for apt and resourceful maintenance policy to be developed and instituted to keep the equipment and machines in good working conditions so that the system can perform as intended and avoid service disruption. Quality of network service delivery in Nigeria is adversely affected by incessant network failure due to breakdown of cell site transmission equipment and the existing maintenance management capability is not providing timely and durable solution to the problem. Nwakanma et al (2012) listed interconnectivity and tariff system a most significant factor affecting the growth of Teledensity (telecommunication usage) in Nigeria. This view is in agreement with Shoewu and Edeko (2011) who concluded that operators need to improve on their service quality which has been a challenge not as a result of the traffic channel (because it is readily available) but from other factors including the congestion of the SDCCH. Breakdown of the equipment and maintenance management approaches result to longer downtimes, expensive emergency repair cost, heavy revenue losses and impaired corporate image. Considering the technological complexities associated with cell site transmission equipment and its relatively uncharted waters in Nigeria, this study provide insight to the type of maintenance policy to address the incessant breakdowns as this will enhance service delivery through effective maintenance policy. The result of study conducted by Adenikinju (2005) shows that telecommunication is second to the highest major obstacle in Nigeria (34%) after electricity. The benefits of Information Technology are being threatened by incessant network failure, unreliability, excessive downtimes, and low quality of services and lack of customer satisfaction. The equipment and component failures without effective maintenance policy have aggravated the communication problems especially since the introduction of GSM. Though better than analogue telecommunication system, improvement in the GSM service delivery is imperative considering the pace and level of development in commerce, industry and political administration in Nigeria. Also, undefined and ineffective maintenance policy result to maintenance cost and time overruns as well as shoddy maintenance work delivery.

Research gap exists in the maintenance policy option for the IT transmission equipment. Many research have been conducted on the factors affecting cell site locations, causes of component breakdowns and modeling of downtimes of the GSM facilities (Ubani 2013) but without evolving maintenance policy that will reduce downtimes to the barest minimum.

The objective of the study is therefore to fashion out appropriate and effective maintenance policy for cell site transmission equipment so as to foster functional reliability of the system and quality GSM service delivery. The result of the study will help to minimize GSM service interruption, maximize operation capacity utilization and useful life of cell-site transmission equipment, minimize operating cost and identify the major cause of breakdown so as to minimize the frequency of failures or breakdown.

A study on modeling of downtimes of operating system of telecommunication facilities for effective project communication and management information system by Ubani (2013) shows that failure of Cell Site or Base Transceiver Station (BTS) transmission equipment ranks second as contributory factor to downtimes of GSM facilities. Strategy to put this equipment in proper working condition through effective maintenance policy is therefore a recipe for addressing these problems militating against optimal maintenance and performance of GSM facilities. Project management capabilities and competences are therefore advocated for abating incessant failure of these information network facilities through effective maintenance policy. Cadle and Yeates (2008) have grouped information system projects into nine broad types; among which is infrastructure project. This type includes ones to introduce or replace hardware, servers or CPs, for example, to put in place communication infrastructures and also sometimes, the physical construction of things like computer suits or fitting out and equipment of a new office building. It therefore becomes especially important to establish firm and realistic timescales for delivery and to examines carefully the interdependencies between tasks, as otherwise time, effort and money can be wasted waiting around for things to be delivered or completed.

The following hypothesis was formulation and tested in the course of the study:

Ho: There is no significant difference in the mean effectiveness of maintenance policies for GSM BTS transmission equipment in Cellular system infrastructure project.

2. LITERATURE REVIEW

In different parts of the world, production or service delivery organizations adopt approaches and policy options to component failures, breakdowns, and maintenance of facilities and equipment. For instance Gaither (1996) avers that Japanese manufacturers detest interruption to production. When a machine breakdowns, a flashing red light goes off at the machine and production workers and repair specialist from maintenance departments work side by side to fix the machines fast so that production can resume. Equipment malfunctions in production and service industries have direct impact on production capacity, production cost, product quality, employee or customer safety and customers' satisfaction. Ubani (2007) have cited a case of production downtime analysis of Delta steel company Ltd of Nigeria. The 1991 annual production plan of the company shows that, out of the 6288 hours available for production between January and September 1990, only 2436 hours (38.74%) were utilized for production. A total of 3852 hours were downtimes caused by production delays, which equipment breakdown and maintenance account for 1001 hours (25.99%). This is an indication that breakdowns and, maintenance of facilities and equipment take very long time. Maintenance management ensures that they are in good working conditions, and it is essential to achieve specified level of quality, reliability and efficient working conditions. Plant maintenance is an important service function of an efficient production or operations system. It helps in maintaining and increasing operational efficiency of plants facilities and thus, contributes to revenue by reducing the operating costs and increasing the effectiveness of production. Maintenance is therefore designed to keep the resources in good working condition or restore them to operating status. Breakdown of equipment and facilities make the workers and machines idle; result in loss of operations in service delivery, delay in schedule and expensive emergency repair. The downtime costs associated with breakdown cost usually exceed the preventive maintenance costs of inspections, service and scheduled repair up to the point M as shown in figure 1. Beyond this optimal point, an increasing higher level of preventative maintenance is not economically justified and it is economical to adopt breakdown maintenance policy.

The optimal level of maintenance activity M is easily indentified on a theoretical basis, and to do this, details of the cost associated with breakdown and preventive maintenance must be known. However, the costs associated with other types of maintenance policies are not considered on this theoretical framework as they need to be explored for deductive inferences. Generally, costs associated with maintenance as posited by Telsang (2010) are downtimes or idle time costs, cost of spares and materials, labour and overhead, losses due to inefficient operations of machines and capital for replacement of machines.

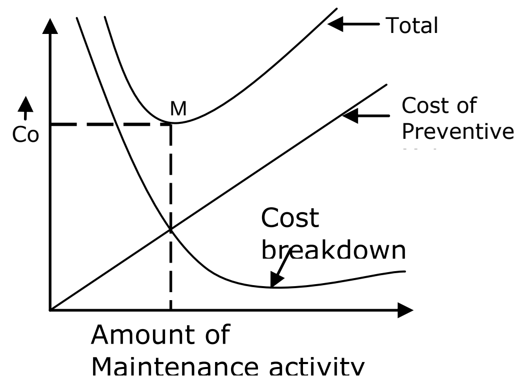

Figure 1: Maintenance cost. (Source: Telsang 2010)

Various forms of maintenance and their relationship are presented in figure 2 shown below:

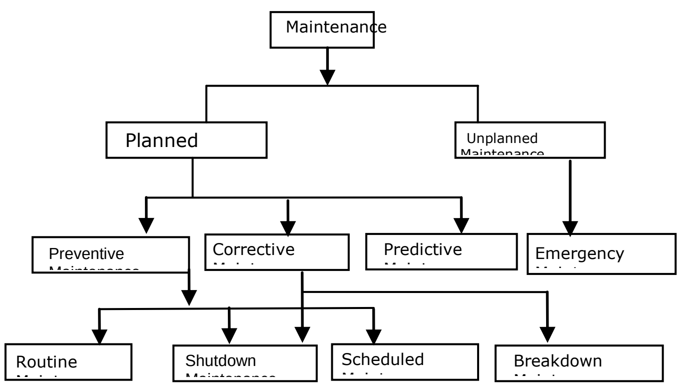

Figure 2: Various forms to maintenance (Sources: Telsang 2010).

Each approach to maintaining facilities is appropriate for different circumstances. Breakdown maintenance or what Slack et al, (2004) refer to as run to break is often used where repair is relatively straight forward so, consequences of failure are small, where regular maintenance is very costly (making preventative maintenance (PM) expensive) or where failure is not at all predictable (so there is no advantage in PM because failure is just as likely to occur after repair as before). PM is used where the cost of unplanned failure is high (because of disruption of normal operations) and where failure is not totally random, so maintenance time can be scheduled before failure become very likely. Predictive/Condition Based Maintenance (PCBM) is used where the maintenance activity is expensive either because of the cost of providing the maintenance itself, or because of the disruption which the maintenance activity causes to the operations. It could be on these premises that Slack et al, (2004) posits that most operations adopt a mixture of these approaches because different elements of their facilities have different characteristics. For instance; in motor car maintenance, the engine is a subject of preventative maintenance through change of oil, the car lamp bulb are subjects of run-to-breakdown maintenance and tyres undergo CBM condition. There could be other forms of maintenance such as opportunistic and design out maintenance. As computers have been universally absorbed into management information systems in all types of organizations, maintenance departments have also been affected by this development. Five general areas in maintenance where computer assistance is commonly used today are:

i. Scheduling maintenance projects,
ii. Maintenance cost reports by production department, cost categories and other classification.
iii. Inventory status reports for maintenance parts and supplied
iv. Diagnosis and Parts failure data
v. Operations analysis studies, which include computer simulation, waiting line (queuing theory) and other analytical program.

Information from the uses of computers can provide managers in maintenance operation with the necessary failure patterns, cost data and other information fundamental to the key maintenance decisions. Computers are therefore the indispensible integral part of Information Technology (IT). Stevenson (2007) describes IT as the science and use of computers, and other electronic equipment to store, process and send information. IT is heavily ingrained in today's business operations. These include electronic data processing, the use of bar code and radio frequency tags to identify and track goods, devices used to obtain point-of-sale information, data transmission, e-mail, the internet, e-commerce, and more. The transmission of the information and signals are usually facilitated by cell site equipment or BTS.

2.2. CONFIGURATION OF GSM INFRASTRUCTURE

Structure of Cell Site or BTS for GSM Transmission Equipment is technologically complex and without effective maintenance policies on ground and, therefore could be responsible for vulnerability to breakdown and failures. For instance, a cell-site is a cellular telephone site where antennas and electronic communication equipment are placed usually on a radio mast, tower or other high place, to create a cell or adjacent cell in a cellular network. In the GSM network, the technically correct term is Base Transceiver Station (BTS) which is a subsystem of Based Station Subsystem (BSS) development. BTS is a piece of equipment that facilitates wireless communication between user equipment and a network. Users' equipment is devices like mobile phones (handsets), computers with wireless internet connectivity etc. BTS can be applicable to any of the wireless communication standard; it is generally associated with mobile communication technology like GSM. BTS comprises of radio transmission and reception equipment for communication to and from mast over the air interface. It has the following; Base Station subsystems such as packet control unit, transcoder, sector antenna, Base Station Controller (BSC). Packet control unit performs some of the processing tasks of the BSC, but for packet data. Transcoder is used for transcoding voice channel coding between the coding used in the mobile network and the coding used by the world terrestrial circuit-switch network; the public switch network and telephone network. The BSS is in charge of radio interface management, and sector antenna for receiving and sending out radio wave. Similarly a BTS in general has the following parts or components; transceiver, power amplifier, combiner, duplexer, antenna, alarm extension system, control functions device and based band receiver unit. (Wikipedia, 2013; Agrawal and Zing, 2006; Sharma, 2006)

Though the term BTS can be applicable to any of the wireless communication standards, it is generally associated with mobile communication technologies like GSM, wireless internet etc. In this regard, a BTS therefore forms part of the Base Station Subsystem (BSS) development for system management. It may also have equipment for encrypting and decrypting communications, spectrum filtering tools (band pass filters), etc. Antennas may also be considered as components of BTS in general sense as they facilitate the functioning of BTS. Typically, a BTS will have several transceivers (TRXs) which allow it to serve several different frequencies and different sectors of the cell (in the case of sectorised base stations). A BTS is controlled by a parent base station controller via the Base Station Control Function (BCF). The BCF is Implemented as a discrete unit or even incorporated in a TRX in compact base stations. The BCF provides an Operations and Maintenance (O&M) connection to the Network Management System (NMS), and manager's operational states of each TRX, as well as software handling and alarm collection. The basic structure and functions of the BTS remains the same regardless of the wireless technologies.

Figure 3 below summarises the GSM Infrastructure

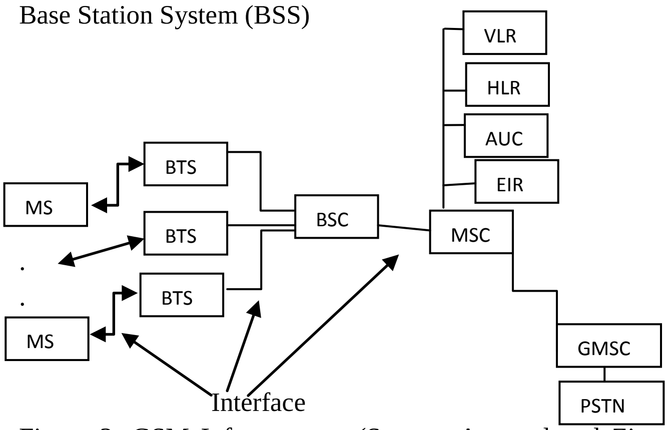

Figure 3: GSM Infrastructure (Source: Agrawal and Zing, 2006)

Key:

MS: Mobile Station
BTS: Base Transceiver Station
BSC: Base Station Controller
MSC: Mobile Switching Centre
EIR: Equipment Identity Registrar
AUC: Authentication Center
VLR: Visitor Location Register
HLR: Home Location Register
GMSC: Gateway Mobile Switching Centre
PSTN: Public Switched Telephone Network

In his own contribution, Blake (2002) examines cell site equipment, and states that the radio transmitting equipment at the cell site operates at a considerable higher power than do mobile phones, but this power is shared among all the channels that are used at the site. Similarly, there must be receivers for monitoring the signal strength of mobiles phones in adjacent cells. Consequently, the cell site equipment is much more complex, bulky and expensive than the individual cell phones. In addition, cell sites often need directional antennas to facilities the division of each cell into sectors. The sites radio equipment is operated by a BSC.

The BSC takes care of an air interface (i.e. the combination of mobile cellular phone and cell-site radio equipment and is called the air interface); assigned channel and power levels, transmitting signaling tones etc. The Mobile Switch Centre (MSC) routes calls along a private copper fibre optic, or microwave network operated by the cellular service providers. Their action is also required in authorizing calls, building, initiating handoffs etc. Sometimes, BSC and MSC are combined and associated with MSC, are data banks where locations of local and roaming mobiles are stored. The complexity of cell site equipment makes it to require adequate care in the supply contract, operations and maintenance usually through ICT network servicing consultants. For instance, included in the portfolio of network services by Management System GSM Network Ltd; a network servicing company in Nigeria are the following; installation, repair, integration, optimization, maintenance, site selection, site survey, equipment removal, redeployment etc. These services usually enhance every element of network from microwave transmission to antennas, BTS, BSC and MSC. It could be on this premise that Idhammar (2009) gave many reasons which are attributed to inefficiency, overstaffing etc. on why consultants are preferred to operators' managers for maintenance. According to him, if the basic maintenance practices such as planning, scheduling, stores, technical data base etc are not instituted as a way of life, do not make the move of using operators' managers for maintenance. The technological complexities, congestion and aggressive operating environment necessitate the need for employment and institution of proven maintenance management policy and culture for optimal performance.

3. METHODOLOGY

The study adopted opinion survey of research design with area and judgment sampling techniques. The geographical areas covered by the study are the South-South and South Eastern (Niger Delta Region) Nigeria. However the renaissance survey carried out in the maintenance department of the Information and Communication Technology (ICT) companies indicate lack of secondary data and failure statistics on the maintenance operations of the GSM transmission equipment. A sample size of 75 experts was estimated from the population of ICT companies operating in the geographical locations selected for the study. The selected ICT companies are Airtel, MTN and Globacom. They were selected for the study because of their large market shares in the ICT business operations. Similarly, the geographical zones were selected due to harsh weather condition, aggressive operating environment and congestions of the service requirements that render the ICT facilities vulnerable to frequent failure. There is also high service demand in this zone because of massive economic activities such as construction of on-shore and off-shore oil production and transportation facilities, road and building construction projects, high population density, high demand for service and high concentration of GSM BTS. The data used for the study was captured through well structured and standardized questionnaire modeled in likert five point scale and based on the following maintenance policies in an attempt to determine the most effective policy (if any) in the maintenance management of GSM system hardware transmission equipment. The following maintenance policies were identified and examined for their respective effectiveness in BTS transmission

i. Preventive/Scheduled maintenance policy (PSMP)
ii. Predictive/Condition-Based maintenance policy (PCMP)
iii. Mixed Strategy maintenance policy (MSMP)
iv. Corrective/Breakdown maintenance policy (CBMP)

The questionnaire was administered to experts with the operating ICT companies in the zone who are deemed to possess the requisite skills, dexterity and not with less than 5 years cognate experience in maintenance and operation of ICT facilities for service delivery to the teaming customers. The respondents are specialists in the areas of, electrical/electronic, mechanical and telecommunication engineering, and maintenance project management. They were requested to provide, based on their perception, opinion and intuitive reasoning, the extent of agreement or disagreement on the maintenance policies presented in a Likert five point scale format. The method of data analysis adopted for the study is Multiple Comparison Test (MCT) through Friedam-test (F-test). MCT enable the comparison of the means of three or more groups. The two steps necessary for the conduct MCT are:

(i) The Analysis of variance (ANOVA), which determines if there exits at least one means being significantly different from other. i.e. p-value for the ANOVA result is less than the significant level $\alpha= 0.05$ indicating that at least one mean is different. But if p – value is more than $\alpha = 0.05$, there is no significant difference in the means and hence the analysis is over.

(ii) However if the ANOVA's p-value is significant ie p-value <0.05 the test will proceed with the MCT to determine which means are significantly different from which other means. The MCT compares all the possible pairs of means and indicate the pairs that are significantly different at the probability level of $\alpha = 0.05$, being the error margin used for the study.

Table 1: Questionnaire distribution and returns

Focus ICT Company	Number Allocated to each Company	Number Returned for each Company	Percentage of Total Return
Airtel	25 (33.33%)	21 (84%)	28.00
MTN	25 (33.33%)	23 (92%)	30.67
Globacom	25 (33.33%)	20 (80%)	26.57
	75 (100)	64	85.34

Table 2: Responses by attitude on the significant difference on the effectiveness of maintenance policies

Focused ICT Company	SD	D	N	A	SA	TOTAL
Airtel	1	2	5	6	7	21
MTN	3	2	4	8	6	23
Globalcom	-	1	7	6	6	20
TOTAL						64

Table 3: Responses by Professionals

Focused Professionals	Airtel	MTN	Globacom	TOTAL
Electrical/Electronics Engineers	6	8	6	20
Mechanical Engineers	2	4	3	9
Telecommunication Engineers	7	6	5	18
Maintenance Project Managers	6	5	6	17
TOTAL	21	23	20	64

4. RESULT OF MULTIPLE COMPARISON (NON PARAMETRIC, FRIEDMAN) TEST USING SPSS ON THE DATA SET.

The sample size used for the analysis is 64 based on the number of returned questionnaires.

Table 4: Ranks of Maintenance Policies

Name of Policies	Mean Rank	Ranking Order
Preventive/Scheduled maintenance policy (P/SMP)	2.90	Second
Predictive/Condition based maintenance policy (P/CMP)	3.34	First
Mixed Strategy maintenance policy (MSMP)	1.95	Third
Corrective/Breakdown maintenance policy (C/BMP)	1.81	Fourth

Source: Computer Analysis Result

Table 4 indicates the mean rank and ranking order of the effectiveness of maintenance policies.

Table 5: Test Statistics[a]

N	64
Chi-Square	76.557
Df	3
Asymp. Sig.	.000

a. Friedman Test.

Source: Computer Analysis Result**.**

The result of multiple comparison via Friedman test statistic (F– test) in table5 shows that the calculated; Chi-Square = 76.557 and asymmetric significance of 0.000 < 0.05; the test is conducted at 0.05 level of significance. The result indicates that the hypothesis is significant at 5% level of significance. The study therefore concludes that the test of hypothesis is significant at 5% level of significance and therefore; establishes that there is significant difference in the mean effectiveness of maintenance management policies for the GSM transmission facilities of the IT infrastructure projects in the Niger Delta region of Nigeria. Table 4 also presents mean rank for effectiveness of maintenance management policies applicable to GSM transmission facilities as to reduce the downtimes to the barest minimum and enhance efficient service delivery. The mean rank in table 4 could serve as a priority rule which can be used to establish the most effective maintenance policy. The study concludes that predictive/condition based maintenance (PCMB) policy ranks the highest with 3.34, and therefore, selected and established as the most effective and appropriate maintenance management policy for downtimes reduction and quality GSM service delivery. The policy will also ensure reliability and efficiency of GSM transmission equipment. It is hoped that uninterrupted and quality service delivery would be achieved by adopting PCBM policy in the maintenance project of GSM infrastructure.

The study has therefore fashioned out the most appropriate and effective maintenance policy for GSM transmission facilities in order to ensure timely completion of the maintenance project.

5. RESULTS AND DISCUSSION

From the results of the analysis based on the data obtained from opinion survey of the respondents; PCBM policy was considered most effective, appropriate and preferred to other policies in maintenance projects of GSM transmission facilities. The existing maintenance policy, which is the preventive/schedule maintenance policy, lacks merit in tackling the problems of unpredictable failure and low level of capacity utilization of GSM transmission facilities. Contrary to preventive/schedules maintenance policy which based on routine schedule maintenance of the facilities, and which fails to consider the level of usage which may be either underutilized or over utilized between span and interval of the schedule maintenance. For instance, since the power outage is a major contributor of breakdown and downtimes; (Ubani , 2013) it is unpredictable on when public power will come or how long it will last in addition to being erratic in nature. For instance, in some periods of time, public power could be available for a long time or auto-generators may be overloaded or operated for a long time without interruption until the scheduled maintenance period. As a matter of policy, it means that the facilities will be overloaded before maintenance, which may result to catastrophic failure and permanent damages. Very long downtimes are therefore imminent. On the other hand, when there is little or no power supply to operate the facilities or that the auto-generators are not fully utilized till the scheduled maintenance time, also as a matter of policy, maintenance work must be implemented but prematurely; thus leading to waste of scare resources and time. Stopping the machines or transmission equipment to effect changes when it is not strictly necessary to do so would take it out of action for long period and reduce its utilization. (Slack et al, 2004).

PCBM policy means effecting maintenance actions only when impending faults are detected with sensory devices or when there are changes in the operating characteristics or physical conditions of the facilities. Therefore PCBM attempts to perform maintenance activities only when the facilities require it. It enhances high utilization of facilities necessary for cost and time effective maintenance operations.

PCBM policy is preferred to others because it usually involves prior monitoring of the vibrations and other operating characteristics of the transmission facilities before failure occurs. The result of the monitoring and diagnosis could be used to decide whether the facilities could be stopped and maintained or not. Rushton (2009) describes PCBM as comparatively a newer maintenance technique. According to him, it makes use of human sensors or other sensitive instrument such as audio gauges, vibration analyzers, amplitude meters, pressure, temperature and resistance strain gauges, etc to predict trouble before the equipment fails. Even simple hand touch can point out many unusual equipment conditions and thus predict troubles. Capacity utilization of the GSM transmission facilities would be enhanced because in PCBM. Equipment conditions are measured periodically or on a continuous basis and this enable maintenance crew to take a timely action such as equipment adjustment, repair or overhaul (Slack et al, 2004). They also assert that PCBM extends the service life of equipment without fear of failure. The breakdown/corrective and mixed strategy maintenance policies are considered to be ineffective and inappropriate for GSM transmission facilities because of highly perceived idle times of the facilities during downtimes. The breakdowns may be overdue, severe and complex thereby making timely and effective maintenance unrealistic. Also much time is expected to elapse from the time the facilities fail, procurement of component parts, to the time of realization of full repairs, due to complexity and magnitude of damages caused by the failure. The study further unveil through personal interview that; the socio-economic activities of subscribers and customers are in shamble most of the time as a result of breakdown or downtimes of GSM transmission facilities. Also, no defined maintenance policy on ground as the operators, and maintenance crew for GSM transmission equipment usually apply either breakdown/corrective or preventive/scheduled maintenance policy. The causes of breakdown and failure of GSM facilities are due to power supply outage, the failure of BTS component and transmission equipment. The existing maintenance management practices are not very effective as they prolong downtimes in an attempt to detect the cause(s) of component failures after breakdowns and to effect maintenance work.

6. CONCLUSION

The result of multiple comparison tests as shown in tables 4 and 5 established priority rule for selecting the maintenance policy in their order of significant ranking of effectiveness level when applied to maintenance projects of GSM transmission equipment. From the test, predictive/condition-based maintenance policy ranks first in effectiveness and therefore should be adopted for GSM BTS transmission equipment.

The result of this study will help in reducing the frequency of downtimes by predicting and abating component failure of GSM transmission equipment through failure prediction and analysis, and enhancing the reliability of the transmission facilities through predictive/condition based maintenance policy. The adoption of appropriate maintenance management policy would ensure timely and cost effective maintenance project whenever GSM transmission facilities or equipment fail. The study would further boost quality and reliability of GSM services delivery to subscribers. The provision of redundancy or backup system in addition to PCBM policy are recommended for ameliorating the problems of downtimes , poor quality of service delivery and disruptions of communication services.

REFERENCE

i. *Adenikinju A. (2005): Analysis of the cost of infrastructure failures in a Developing Economy: The Case of Electricity Sector in Nigeria. African Economic Research Consortium Paper, Nairobi.*

ii. *Agrawal D.P.and Zing Q. (2006): Introduction to Wireless and Mobile Systems. Second Edition. Nelson*

Publisher a division of Thomson Canada Limited. ISBN: 0-534-49303. Pp 190-191, 229-230.

iii. *Blake R. (2002) Electronic Communication System, Second Edition. Delmar. Fifth Edition. Pearson prenticeHall. www.pearsoned.co.uk*

iv. *Chandra P. (2006) Project Planning, Analysis, Selection, Financing Implementation and Review. Sixth Edition. Tata McGraw Hill Publishing Company Ltd, New Delhi.*

v. *Idhammer L. (2009) Can Operations Managers Manage Maintenance http://www.idco.com/article.operations.*

vi. *Nwakanma I.C., Asiegbu B.C. and Amadi E.C. (2012): Quantitative Analysis of Factors Affecting Teledensity Growth in Nigeria. Microwave International Journal of Science and Technology Vol.3, No.1. www.mijstedu.com. Pp 25-35.*

vii. *Rushton J.W. (2009) Effective Maintenance Management Using Planned and Preventive Maintenance http://www.mechanicalindetail.info/ Machine-tool-maintenance/correct.*

viii. *Sharma S. (2006): Wireless and Cellular Communications .Second Edition, 2010 reprint. S.K.Kataria and Sons, New Delhi India. Pp 515-521*

ix. *Shoewu O. and Edeko F.O. (2011): Out-going call quality evaluation of GSM network services in Epe ,Lagos State. American Journal of scientific and Industrial Research 2(ii):409-417. http://www.scihub.org/AJSIR*

x. *Slack N., Chambers S. and Johnston R. (2004) Operations Management. Fourth Edition. Prentice Hall Financial Times. www.booksitesnet.*

xi. *Stevenson W.J. (2002): Operations Management. International/Seventh Edition. McGraw Hill, Irwin.*

xii. *Telsang M. (2010) Industrial Engineering and Production Management S Chand and Company, Ram Nagar, New Delhi.*

xiii. *Ubani E.C. (2007) Downtime Analysis in Steel Rolling Mills in Nigeria. International Journal of Development and Management Review. Vol. 2 No. 1 www.ajol.*

xiv. *Ubani E.C. (2013) Modelling of Downtime of Operating System of Telecommunication facilities for Effective Project Communication and Management Information System. International Journal of Advanced Scientific and Technical Research*

xv. *http://www.rspublication.com/ijars/index. html. Issue 3, Vol 1.*

xvi. *Wikipedia (2013 Free Encyclopedia.jump to navigation, search.*