iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** II **Month of publication:** February 2020

DOI: http://doi.org/10.22214/ijraset.2020.2070

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

Optimization of Line-of-Sight Link Budget for Mobile Network Application over Jos, A Semi-Temperate Region of Nigeria

Igbekele O. J. [1], Ogherohwo E. P. [2], B. J. Kwaha[3], Zhimwang J. T[4]
[1, 2, 3]*Department of Physics, University of Jos, Nigeria.*
[4]*Department of Physics, Federal University Lokoja, Nigeria.*

Abstract: This paper presents the optimization of line-of-sight link budget for mobile network application over Jos, a semi-temperate region of Nigeria. There were 10 remote and one hub sites from which the experimental data were taken. The measurement materials used were made in two categories as Drive Test Measurement Materials and Setup Configuration Materials. The drive test measurements was carried out concurrently with the weather station measurements, Radio Network Optimizer (RNO) measurements, mobile backhaul radios measurements, with synchronized clocking reference, for concurrent timing analysis. The bit error rate on radio performance analysis was calibrated with the rainfall rate for rain parameters measurements. A bit error tester, BERT is employed for calibration. It measures the BER for a given transmission. The research revealed that instances of slight under-budgeting observed by the Study in JHL064 and JHL025 as 35.01dB and 34.99dB respectively when tested with the Study calculated values 35.20dB and 35.90dB respectively. Another vital observation made was that, the instances of excess fade margin budget as estimated by ITU-R for JHL016 (43.77dB/34.60)dB, JHL077 (40.15/37.10)dB and JHL001 (41.22/39.50)dB was inconsequential. Therefore, not less than 0.6m antenna dish will be required in Jos Lowland for the terrestrial link design at 18G_XMC2_128Q_14M_78M work mode in order to achieve successful delivery of at least 4.15Mbps download speed for data service and +20 SQI of voice quality at minimum required RSL of -37.2dBm at rain attenuated signal losses not less than 100dB in Jos Lowland.
Keywords: Line-of-sight, Link budget, 2G Network and 3G mobile network

I. INTRODUCTION

A link budget is a design tool that provides a basic estimation and evaluation of link feasibility. The computation should not only provide theoretical approximations but experimental measurements producing verifiable empirical data reflecting the real-world variables for accurate system performance. The design of a reliable radio link must adequately meet the minimum required margin by deploying suitable antenna able to achieve adequate gain requirements while being mindful of the limits on site transmitter maximum radiated power for radio channel interference regulations (Seybold, 2005).

Line-of-sight is a direct propagation of radio waves between antennas that are visible to each other. This is the most common of the radio propagation modes at VHF and HF. When considering line-of-sight (LOS) propagation, it may be necessary to consider the curvature of the earth. The curvature of the earth is a fundamental geometric limit on LOS propagation. In particular, if the distance between the transmitter and receiver is large compared to the height of the antennas, then LOS may not exist. The simplest model is to treat the earth as a sphere with a radius equivalent to the equatorial radius of the earth. From geometry (Seybold, 2005)

$$d^2 + r^2 = (r + h)^2 \quad (1)$$

So

$$d^2 = (2r + h)\,h \quad (2)$$

Mobile network is a network of base stations that provide coverage enabling the use of mobile phones for calls, text messages and data services. A cell phone is an electronic transceiver used for two-way radio telecommunication over a cellular network of base stations known as cell sites (Frieden, 2009).Mobile communications also offer a lot of services ranging from mobile Internet, multimedia and electronic mails services (Mughele et al., 2015).

Microwave is a line-of-sight wireless communication technology that uses high frequency beams of radio waves to provide high speed wireless connections that can send and receive voice, video, and data information. In order for microwave antennas to achieve clear transmission there must be an uninterrupted path between the transmitting antenna and the receiving antenna termed line of sight (LOS).

Terrestrial microwave systems use relatively low power transmitters with high-gain parabolic or hog-horn antennas. By concentrating the transmitted power into a narrow beam, these antennas increase the effective power and reduce interference to and from other systems. There are limits to antenna gain, however. Gain greater than 45dB should be avoided because antennas with this much gain have such narrow beam width (less than one degree) that mounting requirements are severe – slight motion of an antenna tower due to wind can be sufficient to cause signal loss with such narrow antenna beams. Above a certain threshold of frequency, attenuation due to rainfall becomes one of the most important limits of the performance of line-of-sight (LOS) microwave links (Green, 2004). Line-of-sight links usually operate in the GHz frequencies, therefore are very susceptible to rain. Feed lines between transmitter and/or receivers and antennas are almost always constructed from waveguide at frequencies above 2GHz, to reduce losses. At lower frequencies, coaxial cable may be used. Rain fades start to become a concern at around 5GHz and is more evident at frequencies above 10 GHz (Seybold, 2005). Jos-Nigeria is under the effect of both tropical and temperate climate (Nanvyat et al., 2017), otherwise described as semi-temperate climate zone. But significant differences in climatic conditions and therefore in precipitation characteristics are observable between diverse areas of the state as a result of irregular topography, compared with most parts of Nigeria. Therefore, the study of the climatic zones in Jos-Nigeria is a very vital issue when dealing with the design of link budget using existing rain attenuation and propagation models, owing to the peculiarities of Jos semi-temperate savanna zone, the climate and topography characterized with tall mountains, high surface pressure and mountain barriers. Tall mountains force air over them while rising air forms cloud causing precipitation on the side where the air is rising and cool. The dry air however descends on the other side of the mountains. Region's precipitations are affected by factors like latitude, the distribution of air pressure systems and global winds, and the existence of a mountain barrier. All these factors are attributable to Jos region, giving to the need for local developed data source for the link budget design. High altitude locations such as Jos Plateau and the Eastern border highlands (Mandara and Adamawa highlands, Obudu and Mambilaplateux) have a cooler and rainier climate than their surrounding lowlands. The International Telecommunication Union Radio communication Sector (ITU-R) has provided a methodological approach for predicting rain attenuation on any terrestrial radio link. Emphasis on the inappropriateness of the ITU-R method in tropical regions has been reported in a number of published research works (Freeman, 2007). During rainfalls, absorption of the signals by the raindrops causes signal attenuation. Atmospheric disturbances such as thunderstorms also distort the signal and cause unacceptable number of errors (Clark, 2000). Precipitation based path loss is difficult to predict, although it is possible to make some estimation using the International Telecommunication Union-Radio Communication sector to calculate the effect of precipitation in the region of operation for a specified period and make predictions for the possible future effects. . The developments of improved and more accurate rain attenuation models applicable to semi-temperate regions in Jos- Nigeria thus require more experimental data from the region. The underlying reason for investigating variability in different mobile services quality in Jos region which fall into two rain climatic zones of tropical and semi-temperate, is the necessity and reason for this research. GSM network quality issues in Jos compared to other regions have removed unresolved mainly due to the peculiarity of its nature and climate conditions. The transformation of radio wave is affected by various mechanics which affect the reliability of received signal. There is a radio signal level required for certain level of voice clarity and high-speed data transfer, over a microwave radio link. The power level measurements, must however be ensured to avoid over transmission or power overshooting, leading to radio channels interference or undue high cost of transmission, it is therefore imperative to determine minimum required received signal level (RSL) for a specific service type of mobile network using microwave backhaul.

II. MATERIALS AND METHODS

There were 10 remote and one hub sites from which the experimental data were taken for this study. The main hub site was located at Jos Media Gateway, MGW901 (9^o 54'N, 8^o, 53'E) 4123ft.The 11 study locations were grouped into 2 clusters, Jos Highland (JHL) and Jos Lowland (JLL). The highland clusters are JHL025 (9^o, 50'N, 8^o, 54'E), JHL016 (9^o, 53'N, 8^o, 52'E),JHL064 (9^o, 52'N, 8^o, 54'E), JHL077 (9^o,52'N, 8^o, 54'E), MGW901 (9^o 54'N, 8^o, 53'E),JHL001 (9^o, 54'N, 8^o, 53'E) while the lowland clusters are JLL006 (9^o, 57'N, 8^o, 52'E),JLL024 (9^o, 58'N, 8^o, 53'E), JLL011 (9^o, 57'N, 8^o, 53'E), JLL012 (9^o, 55'N, 8^o, 53'E), JLL010 (9^o, 56'N, 8^o, 53'E), JLL048 (9^o, 56'N, 8^o, 55'E).

The tools and equipment used for the study were subjected to pre-data configuration and calibration to ensure that readings were taken to correct accuracy. The measurement materials used were made in two categories as highlighted below:

1) *Drive Test Measurement Materials:* Transmission Evaluation and Monitoring System (TEMS) investigator set, Drive Test vehicle kitted with TEMS software pre-loaded Personal Computer (PC), Anritsu MP1800A and Huawei RTN605 NX seris in-built bit error tester, functional 2G and 3G enabled mobile sets, a geographical GARMIN handheld, Global Positioning System (GPS) receiver and omni directional antenna.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

2) *Setup Configuration Materials:* 2G/3G BTS cell sites backhauled on 13GHz/18GHz microwave links of 0.6 and 1.2 parabolic antenna, DAVIS vantage weather station integrated with wireless console and data logger storage, the digital signal meter for output display of digital signal processing, the spectrum analyser for logging samples of signal power levels, mobile work stations: Laptops, storage disk and live Radio Network Optimization (RNO) system.

A. *Experimental Setup Calibration*

The drive test measurements was carried out concurrently with the weather station measurements, Radio Network Optimizer (RNO) measurements, mobile backhaul radios measurements, with synchronized clocking reference, for concurrent timing analysis. The bit error rate on radio performance analysis was calibrated with the rainfall rate for rain parameters measurements. A bit error tester, BERT is employed in this study for calibration. It measures the BER for a given transmission. It consists of pattern generator that transmits a defined test patter to the test system. It also has an in-built error detector, connected to the system to count the errors generated by the test system. The feature of the BERT that allows the calibration of the rain rate with the error bit rate is its clocking reference. It has a clock signal generator to synchronize the pattern generator and the error detector. Figure 1 is the flow chart showing the procedure for the stages of research.

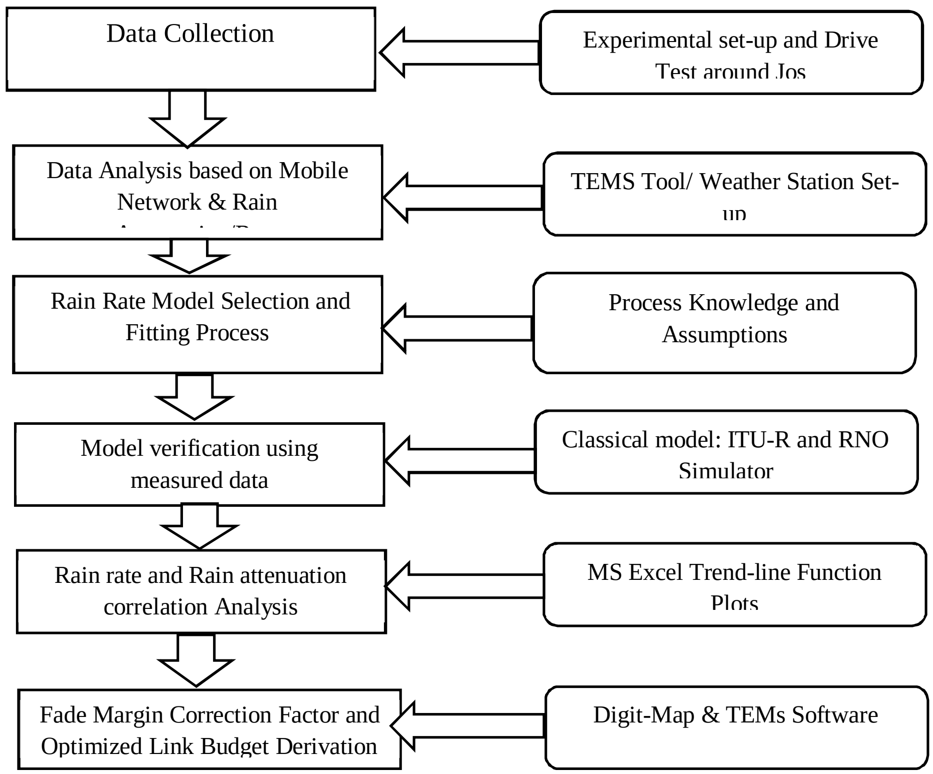


Figure 3: Procedure for the stages of research

B. *Drive Test Measurement*

The study took measurements in different locations within Jos. Figures 2 show the outdoor and indoor units for radio signal attenuation measurements and the drive test setup for mobile stations key performance indicator (KPI) Parameters for Optimization. Eleven 2G and 3G sites were covered by drive test measurements at different locations from each node bearer (Node-B) and base transceiver station (BTS) cell location. Two sets of drive test were repeated for each round of measurement as follows:

1) A preliminary drive test (DT) under clear weather condition was carried out at 11study locations in Jos for 4 weeks at different clear sky weather conditions. The average of the best four measurements were computed.
2) The second round of drive test (DT) under different rain intensities were taken at 11 experimenting locations in Jos. The required radio parameters were taken from the corresponding cell sites and the backhaul links using both the field DT tools and the graphical user interface (GUI) from the network management centre/radio network optimization (NMC/RNO) monitoring servers for the real time data capturing and analysis.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

3) A preliminary drive test (DT) under clear weather condition was carried out at 11study locations in Jos for 4 weeks at different clear sky weather conditions. The average of the best four measurements were computed.
4) The second round of drive test (DT) under different rain intensities were taken at 11 experimenting locations in Jos. The required radio parameters were taken from the corresponding cell sites and the backhaul links using both the field DT tools and the graphical user interface (GUI) from the network management centre/radio network optimization (NMC/RNO) monitoring servers for the real time data capturing and analysis.

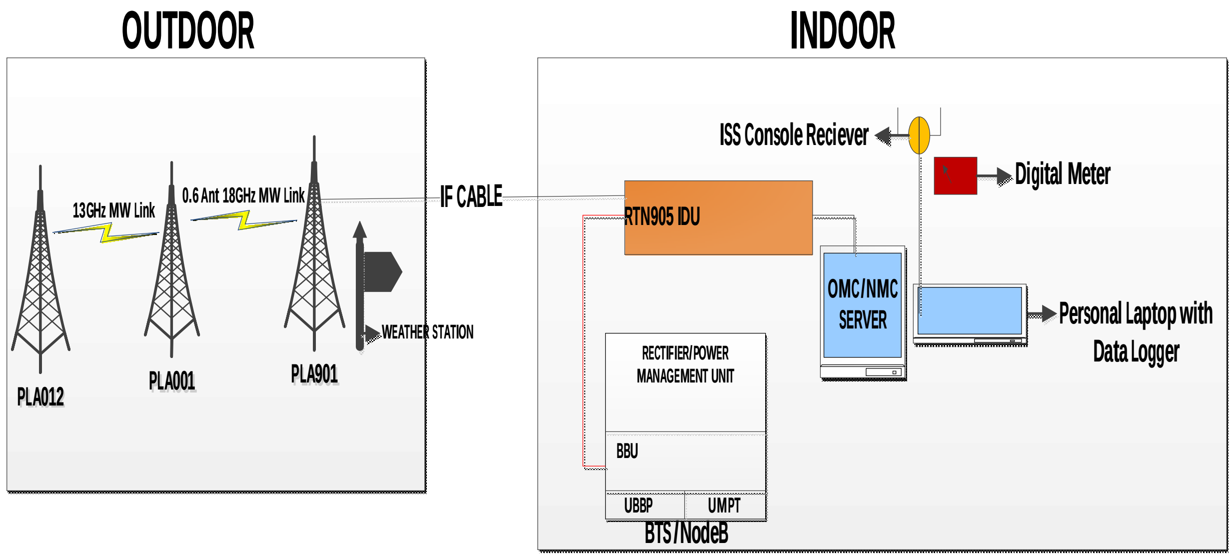


Figure 2: Drive Test Setup for Mobile Stations KPI Parameters Optimization

C. To Calculate the Actual Received Signal level (RSL) using ITU-R Model

The system path losses may unnecessarily occur due to unguided path length estimation as a result of unnecessary longer transmission line. Careful estimation of path loss is a key factor in radio link design. The actual power received (R_xSL), effective isotropic radiated power (EIRP) and the free space loss (FSL) are given by (Young, 2002)

$$R_xSL = EIRP - FSL + R_X\ antenna\ gain - cable\ losses \quad (3)$$

This equation can be expanded as;

Actual RSL = Rx Signal = (Tx power – Tx Coax Cable loss + Tx Ant Gain) – FSL + (Rx Connector Loss) (4)

EIRP = Transmitter Antenna Gain (dBi) + Tx power (dBm) (5)

$$FSL = 92.45 + 20\log(D) + 20\log(F) \quad (6)$$

Where D and F are the distance in km and frequency in GHz respectively

To calculate RSL_{ITU} using ITU-R given parameters: transmit power, Tx = 20dBm

Frequency, f = 18.7 GHz, connector/ Cable loss = 0.5dB, antenna gain(G) = 32.8dBi.

The EIRP is obtained using equation (6)

EIRP = 32.8 + 20 = 52.8dBm

Also, for FSL at 18.7GHz,

Substituting the value of D = 2.376km and f = 18.7GHz into equation (6) yields;

$FSL = 92.45 + 20\log(2.376) + 20\log(18.7)$

$= 92.45 + (20\ x\ 0.376) + (20\ x\ 1.272) = 125.41$ dB

Therefore, to compute actual RSL for PLA 010, substituting the values EIRP = 52.8dBm, FSL = 125.41dB, Rx antenna gain = 32.8dB; Connector /Cable losses = 2dB into equation (3) yields

RxSL = 52.7 – 125.41 + 32.8 – 2= -41.91dBm

D. To Calculate the Antenna gain(G_A) Using the study Optimized Received Signal Level (RSL_{opt}) from the Experimental Results for Jos Lowland

From Table Y, calculate using ITU-R given parameter values transmit power, Tx = 20dBm
Frequency, f = 18.7 GHz, connector/ Cable loss = 0.5dB,
Antenna gain (G) dBi is obtained using equation (4)
RSL_{opt}= (Tx power – Tx cable loss + Tx Ant. gain) $-92.45 + 20\log(D_{km}) + 20\log(f_{GHz})$ + (Rx Ant Gain – Rx Cableloss)
for RSL = -37.2
-37.2 = (20 – 1 + $2G_A$ – (92.45 + 32.96)– 1
-37.2 - 19 –126.41=$2G_A$
70.21 = $2G_A$. Therefore, $G_A = \frac{70.21}{2} = 35.105$

Thus, antenna of 35.105dBi gain was actually required as compared to 32.8dBi gain antenna obtained using ITU-R specifications, this shows that the study is consistent with experimental results revealing the ITU-R link budget was under-estimated. There is evidence of resolving the effusive 62.3% packet loss and comparative 1.13 to 4.15Mbps of data download of ITU-R and the study representing drop in download speed by almost 268% under the influence of rain with significant impact.

The antenna gain with respect to effective area is expressed as (Skirvervik et al., 2001)

$$G = \frac{4\pi Ae}{\lambda^2} = \frac{4\pi f^2 Ae}{C^2} \quad (7)$$

Where G is the antenna gain in dBi, Ae is the effective area in m^2, f is the carrier frequency in Hz, c is the speed of light in m/s and **λ** is the carrier wavelength in m.

The correction factor, A_e referred to as antenna effective area is given by (Gautam, 2008).

$$A_e = \frac{G\lambda^2}{4\pi}(m^2) \quad (8)$$

Where G is the antenna power gain and λ is wavelength in meters. The electromagnetic wave length (λ) is obtained using equation (7)

$$\lambda = \frac{3 \times 10^8}{18700 \times 10^6} = \frac{3}{187} = 0.01604$$

From equation (8), substitute **λ** = 0.01604 then $A_e = 0.066m^2$

Recall equation (8), substitute antenna effective area (A_e) = 0.066 and antenna efficiency (η) = 0.4pu to obtain the antenna dish size (D) using equation (8)

$$A_e = \frac{\eta\pi D^2}{4}$$

$$D^2 = \frac{4A_e}{\eta\pi} = \frac{4 \times 0.066}{0.4 \times 3.142} = 0.210$$

$$D = 0.5m$$

Since, the antenna design is in the order of 0.3m, 0.6m, 0.9m, 1.2m, 1.8m, 2.4m, 3m, 3.3m, therefore, not less than 0.6m antenna dish will be required in Jos Lowland for the terrestrial link design at 18G_XMC2_128Q_14M_78M work mode in order to achieve successful delivery of at least 4.15Mbps download speed for data service and +20 SQI of voice quality at minimum required RSL of -37.2dBm at rain attenuated signal losses not less than 100dB in Jos Lowland. Also, min 37.3dB fade margin is required for data at 20dB signal to noise ratio level. However, 22.4dB fade margin was found required for voice at rain attenuated signal losses not less than 100dB in Jos Lowland cluster.

E. To Compute The Antenna Dish Gain Requirement Using The Study Actual Received Signal Level Jos Highland

Recall equation (4) and substitute received signal level, RSL = -43.9dBm and path length, Ds = 2.818km, therefore
RSL= (Tx power – Tx coaxial cable + Tx Ant. gain)
$-92.45 + 20\log(D_{km}) + 20\log(f_{GHz})$ + (Rx Ant Gain – Rx Cable Conn. loss)
-43.9 = (20 – 1 + (2G) – (92.45 + 20log Ds + 20log 1.3)– 1 – (0.5 x 2)
-43.9 = (19 + 2Gain) – (114.73 + 20log 2.818)–2 = -43.9 + 125.728 – 19 = 2Gain
62.828 = 2 Gain
Gain = $\frac{62.828}{2}$ = 31.44

Therefore, Ant Gain G = 31.414 dBi would be required for effective path length 2.818km in Jos Highland for effective data packet decoding.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

III. RESULTS

Table 1: Measured and calculated results for 3G data service for Jos Lowland Cluster

Study Center Code	Transmit Power (dBm)	ITU Fade Margin (dB)	Calculated Fade Margin (dB)	Mobile DL Speed from study RSL at Clear Sky (Mbps)	Mobile DL Speed from study RSL during Rain Attenuation (Mbps)	Packet Loss obtained using study Link Budget
JLL024	20.0	51.05	52.0	4.12	4.10	0.5%
JLL011	20.0	49.8	52.0	4.29	4.27	0.4%
JLL012	20.0	41.22	38.9	4.26	4.24	0.5%
JLL010	20.0	32.54	37.3	4.18	4.15	0.7%
JLL048	20.0	37.21	30.6	4.12	4.11	0.2%

Table 2: Measured and calculated results for 2G voice service for Jos Lowland clusters

Study Center Code	Transmit Power (dBm)	Receiver Threshold Level, RxS (dBm)	Mobile SQI with ITU budget at Clear Sky	Mobile SQI with ITU budget during Rain Attenuation	Mobile SQI with study budget at Clear Sky	Mobile SQI with study budget during Rain Attenuation
JLL024	20.0	-82.0	+23	+19	+21	+21
JLL011	20.0	-82.0	+23	+19	+21	+20
JLL012	20.0	-68.5	+25	+20	+23	+22
JLL010	20.0	-74.5	+22	+20	+21	+20
JLL048	20.0	-68.5	+25	+20	+23	+22

Table 3: Measured and calculated results for 3G data service for Jos Highland Cluster

Study Center Code	Transmit Power (dBm)	ITU Fade Margin (dB)	Study Calculated Fade Margin (dB)	Mobile DL Speed from study RSL at Clear Sky (Mbps)	Mobile DL Speed from study RSL during Rain Attenuation (Mbps)	Packet Loss obtained using study Link Budget
JHL025	21.0	34.99	35.90	4.31	4.30	0.2%
JHL016	24.0	43.77	34.60	4.33	4.32	0.2%
JHL064	21.0	35.01	35.20	4.28	4.26	0.4%
JHL077	23.0	40.15	37.10	4.32	4.30	0.5%
JHL901	15.0	38.31	38.31	4.29	4.28	0.2%
JHL001	20.0	41.22	39.50	4.30	4.28	0.4%

Table 4: Measured and calculated results for 2G voice service for Jos Highland clusters

Study Center Code	Transmit Power (dBm)	Receiver Threshold Level, RxS (dBm)	Mobile SQI with ITU budget at Clear Sky	Mobile SQI with ITU budget during Rain Attenuation	Mobile SQI with study budget at Clear Sky	Mobile SQI with study budget during Rain Attenuation
JHL025	21.0	-69.0	+24	+21	+21	+20
JHL016	24.0	-78.5	+23	+20	+20	+20
JHL064	21.0	-69.0	+24	+21	+21	+20
JHL077	23.0	-75.0	+23	+20	+20	+20
JHL901	15.0	-68.5	+26	+22	+24	+22
JHL001	20.0	-68.5	+26	+22	+24	+23

Table 5: Minimum required radio signal level (RSL) and signal to noise ratio (SNR) in Jos Lowland

Study Site Code	Link Budget Rx Signal Level (dBm)	Remote Site Rx Signal Level (dBm)	Rx Sensitivity or Treshold Level (dBm)	Noise Floor Level	Critical Degraded Signal Level (dBm)	Minor voice Degraded Signal (dBm)	Early Warning Degraded Signal (dBm)
JLL024	-30.95	-30.95	-82.0	-87	-65	-48.2	-30.0
JLL011	-32.2	-32.2	-82.0	-87	-66	-49.7	-30.0
JLL012	-27.8	-27.8	-68.5	-88	-60	-44.2	-29.6
JLL010	-41.95	-41.95	-74.5	-88	-68	-52.1	-37.2
JLL048	-31.29	-31.29	-68.5	-88	-64	-.52.9	-37.9

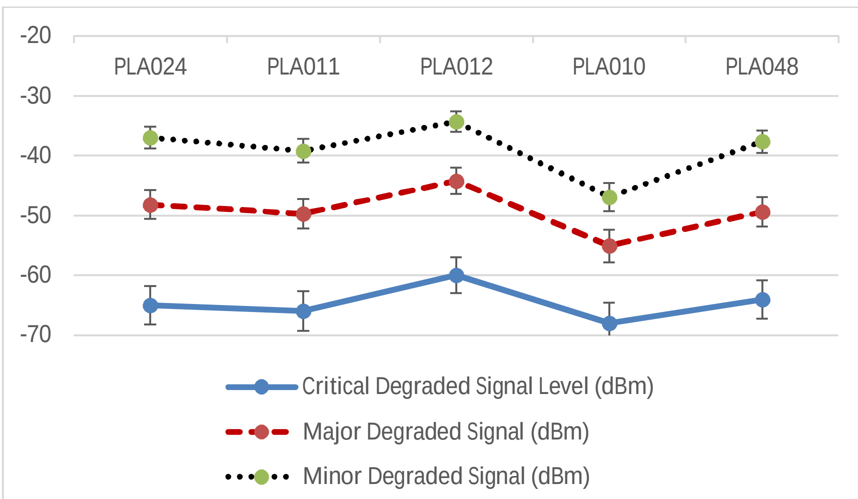


Figure 2: Radio Signal Level (RSL) and Signal to Noise Ratio (SNR) in Jos Lowland

Table 6: Minimum required radio signal level (RSL) and signal to noise ratio (SNR) in Jos Highland

Study Site Code	Link Budget Rx Signal Level (dBm)	Remote Site Rx Signal Level (dBm)	Rx Sensitivity or Treshold Level (dBm)	Noise Floor Level	Critical Degraded Signal Level (dBm)	Minor Degraded Signal (dBm)	Early Warning or Minimum Required RSL
JHL025	-34.01	-34.01	-69.0	-89	-64	-57.4	-33.1
JHL016	-34.73	-34.73	-78.5	-89	-67	-55.1	-43.9
JHL064	-33.99	-33.99	-69.0	-89	-67	-57.3	-33.8
JHL077	-34.85	-34.85	-75.0	-89	-68	-55.4	-37.9
JHL901	-30.19	-30.19	-68.5	-89	-65	-58.0	-30.19
JHL001	-27.2	-27.2	-68.5	-89	-65	-56.0	-29.0

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

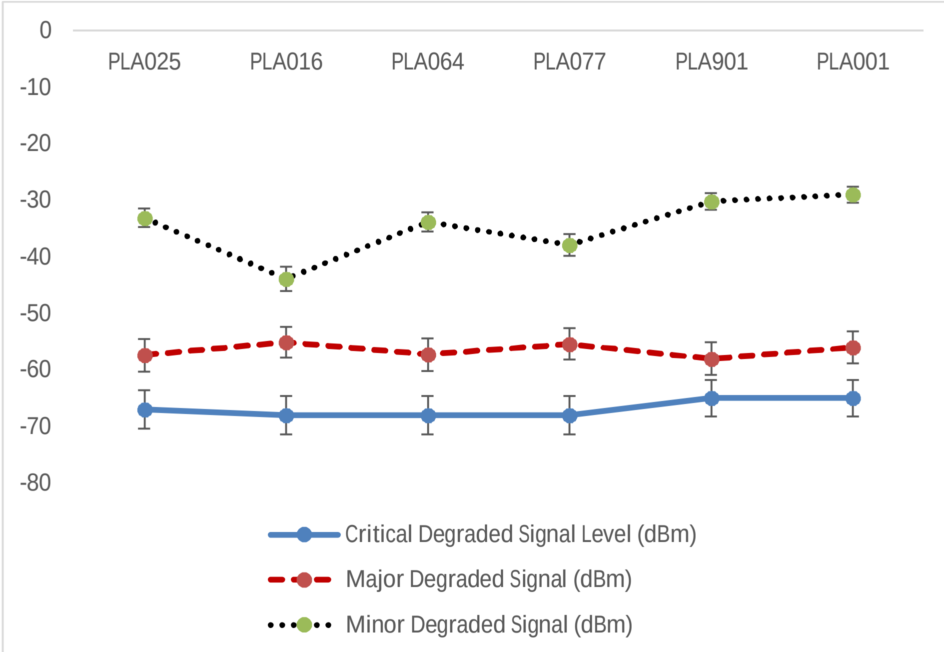


Figure 3: Radio Signal Level (RSL) and Signal to Noise Ratio (SNR) in Jos Highland

IV. DISCUSSIONS

Table 1 and 3 presents the measured and calculated results for 3G data service for Jos lowland and highland clusters respectively. Table 2 and 4 presents the Measured and calculated results for 2G voice service for Jos Lowland and Highland clusters respectively. Table 5 and 6 presents the Minimum required radio signal level (RSL) and signal to noise ratio (SNR) in Jos Lowland and Highland. Parameters like transmit power or receiver's sensitivity were configured to the values of interest. The path length and noise were measured for the purpose of the study. The results in both table 1 and 3 were computed from the measurement taken to test the reliability of ITU-R estimated fade margin for the lowland and highland clusters of Jos both for the clear sky and rain attenuation condition. The same value of the degraded signals was used to calculate the minimum required received signal level for each study location. The parameters of this degradation scenario were used to develop the study calculated fade margin and subjected to different rain attenuated signal losses.

In Table 3, both the ITU-R and Study calculated fade margins of JHL901 were accurately budgeted for 38.31dB, this is shown with the point of intersection in and high download rate of 4.29Mbps and 4.28Mbps during the clear sky test and rain induced attenuation. Also, JHL064 presented 35.01dB and 35.20dB for ITU link budget and Study calculated fade margins respectively. Just like JHL025 presenting 34.99dB against the Study calculated. Thus, both JHL064 and JHL025 recorded the lowest download speed of 3.94Mbps and 3.42Mbps respectively as compared to the record of JHL091 with precise fade margin budget provision recording unflinching 4.29Mbps both in the clear sky and rain induced attenuation situation. Conducting a drive test with the Study minimum required fade margin, signal to noise ratio and received signal power, in all the scenarios, there was a general agreement with ITU-R for sufficient values to the radio link design parameters for the highland cluster as compared to the lowland.

The instances of slight under-budgeting observed by the Study in JHL064 and JHL025 as 35.01dB and 34.99dB respectively when tested with the Study calculated values 35.20dB and 35.90dB respectively, resulted in significant improvement for the QoS performance indices. 4.26Mbps and 4.30Mbps were obtained during rain scenarios culminating into near zero packet loss as compared with ITU budget. Another vital observation made was that, the instances of excess fade margin budget as estimated by ITU-R for JHL016 (43.77dB/34.60)dB, JHL077 (40.15/37.10)dB and JHL001 (41.22/39.50)dB was inconsequential. From the comparative analysis of these 3 study cell sites, JHL016 unflinchingly able to demodulate and decode a successful download and streaming at Study calculated budget at 4.32Mbps, 4.30Mbps and 4.28Mbps as compared to ITU-R 4.36Mbps, 4.31Mbps and 4.28Mbps respectively. By implication, there is no need for the surplus budget, it has only made the design practically uneconomic and defeated the purpose of miniaturization. This simply means, transmit power of JHL016 and JHL077 at 24dBm and 23dBm was of no essence but amounted to sheer waste of resources, as high power more than required is a trade-off to bandwidth resource and inlet carrier interferer. Therefore, rather than deploying 1.2metres antenna and associated high capacity radio frequency (RF) accessories to drive the services, more economical 0.6mtrs antenna and radio accessories would have equally and prudently serve as estimated in the research study. More so, the simple fact that same radio links were deployed to cater for both the voice and data services, and the link fade margin for the required received power level at JHL016 and JHL077, surplus budget for the data service link was not required let alone having same budget for the voice service site.

From Table 5, the minimum required SNR will immune you to early service critical degradation resulting to complete service outage. For example, JLL012 having the likelihood of earliest outage was found to have required the highest 28dB, SNR among the study radio links. Also, JLL048 was found to require 24dB at critical degraded signal of -64dBm. Figure 2 and 3 presented much clearance, in terms of received signal strength to the surrounding noise levels for lowland and highland respectively.

Table 6 give a comparative on how the radio received signal and the background noise levels influenced the SNR in the study. Unlike in the case of the fade margin, whereby the requirements depend on the early warning and minor degraded signal level, the SNR strictly depend on the critical point at which the service outage is imminent

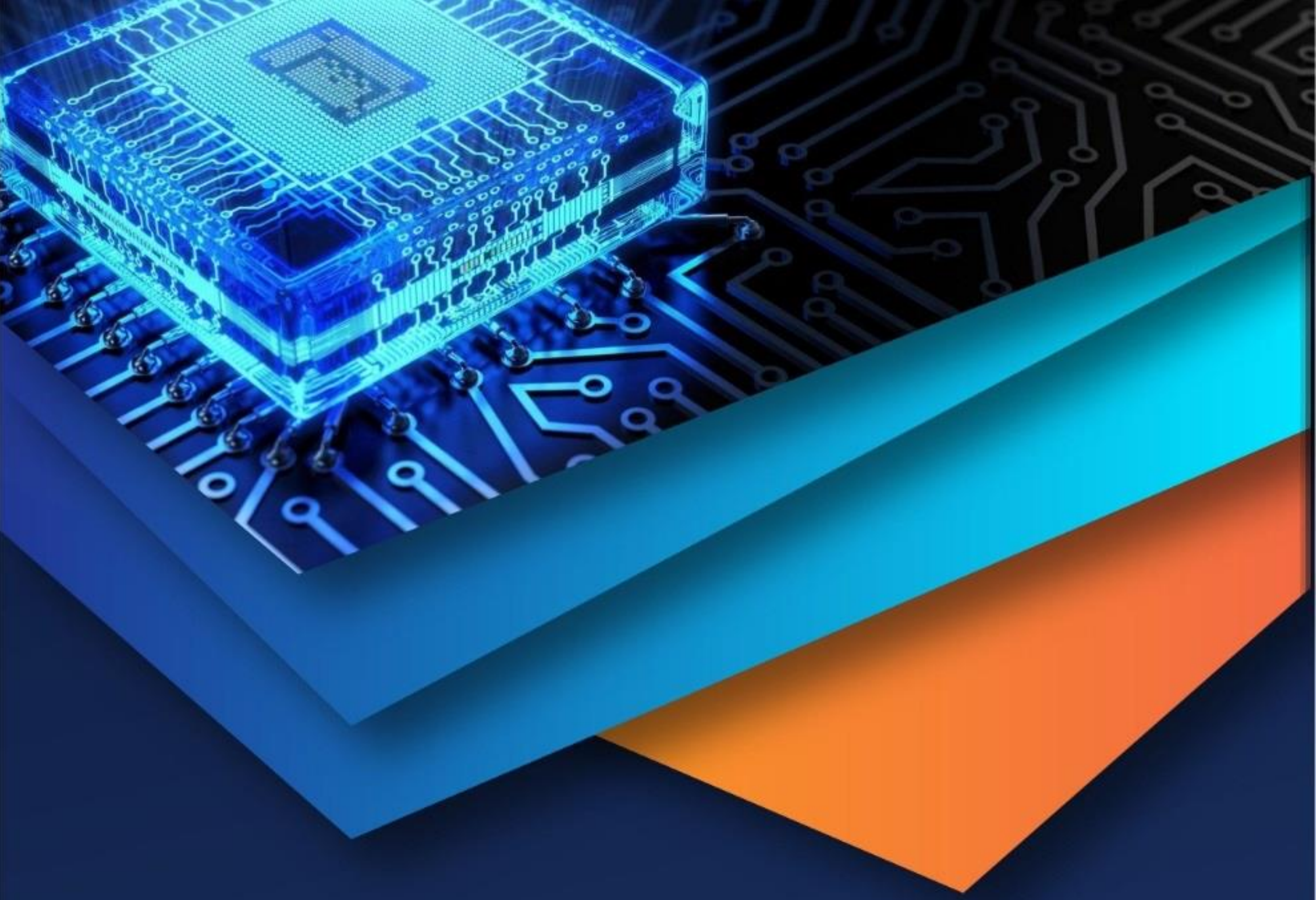
V. CONCLUSSION

Optimization of line-of-sight link budget for mobile network application over Jos, a semi-temperate region of Nigeria was carried out. The research revealed that instances of slight under-budgeting observed by the Study in JHL064 and JHL025 as 35.01dB and 34.99dB respectively when tested with the Study calculated values 35.20dB and 35.90dB respectively. Another vital observation made was that, the instances of excess fade margin budget as estimated by ITU-R for JHL016 (43.77dB/34.60)dB, JHL077 (40.15/37.10)dB and JHL001 (41.22/39.50)dB was inconsequential. From the comparative analysis of these 3 study cell sites, PLA016 unflinchingly able to demodulate and decode a successful download and streaming at Study calculated budget at 4.32Mbps, 4.30Mbps and 4.28Mbps as compared to ITU-R 4.36Mbps, 4.31Mbps and 4.28Mbps respectively. By implication, there is no need for the surplus budget, it has only made the design practically uneconomic and defeated the purpose of miniaturization. This simply means, transmit power of JHL016 and JHL077 at 24dBm and 23dBm was of no essence but amounted to sheer waste of resources, as high power more than required is a trade-off to bandwidth resource and inlet carrier interferer.

Since, the antenna design is in the order of 0.3m, 0.6m, 0.9m, 1.2m, 1.8m, 2.4m, 3m, 3.3m, therefore, not less than 0.6m antenna dish will be required in Jos Lowland for the terrestrial link design at 18G_XMC2_128Q_14M_78M work mode in order to achieve successful delivery of at least 4.15Mbps download speed for data service and +20 SQI of voice quality at minimum required RSL of -37.2dBm at rain attenuated signal losses not less than 100dB in Jos Lowland. Also, min 37.3dB fade margin is required for data at 20dB signal to noise ratio level. However, 22.4dB fade margin was found required for voice at rain attenuated signal losses not less than 100dB in Jos Lowland cluster.

REFERENCES

[1] Clark M.P., (2000). Wireless access networks: fixed wireless access and WLL Networks – design and operation. John Wiley & Sons, UK.
[2] Freeman R L. (2007). Radio system design for telecommunication, 3rd Edition. A Wiley Inter-science Publication, Wiley 2007. John Wiley and Sons Inc. 34-41.
[3] Frieden R. (2009). Telecommunication: Technical Report by Redmond, Microsoft Corporation.
[4] Green, H. E. (2004). Propagation impairment on Ka-band SATCOM links in tropical and equatorial regions. IEEE Antennas Propag. Mag. 46(2), 31–44.
[5] Mughele E.S., Adegbola T., longe O., & Boateng R. (2015). Factor analysis for GSM services congestion – The case of MTN Nigeria. Computing and Information Systems Journal. 15 (1). 4 -15
[6] Nanvyat N., Mulambalah C. S., Barshep Y., Dakul D. A & Tsingalia H. M. (2017). Retrospective analysis of malaria transmission patterns and its association with meteorological variables in lowland areas of Plateau state, Nigeria. International Journal of Mosquito Research. 4(4). 102.
[7] Seybold J. S. (2005). Introduction to radio frequency propagation. Published by John Wiley & Sons Inc.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY