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Full Length Research

Evaluation of Global System for Mobile Communication (GSM) Network Variability for the Safety of Life and Property along the Oron-Calabar Waterway

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The study is aimed at evaluating the GSM network variability along the Oron-Calabar waterway using the four most used cellular network systems (Etisalat, Globacom, MTN and Airtel) in Akwa Ibom and Cross River States, Nigeria. As observed, most water craft using this water route are not installed with Global Maritime Distress and Safety Systems (GMDSS) to aid rapid alerting of shore-based rescue or vessels in the immediate vicinity or communications authorities in the event of an emergency. The lack of improved means of locating rescue team during impending water disaster along the Oron-Calabar waterway has informed this study. The study deployed GSM network cell information lite monitor version 3.15.2 APK to measure the signal strength and quality for the selected network at 1hr intervals along the waterway. To establish the variability among the selected network systems, data obtained were subjected to ANOVA statistics. The results show signal strength mean values of -93.0dBm,-95.0dBm,-101.7dBm and -103.6dBm for Airtel, Etisalat, Globacom and MTN network systems respectively. Similarly, the signal quality evaluated along the waterway shows the mean values of 10.05, 8.47, 5.98 and 5.52 for Airtel, Globacom, Etisalat and MTN respectively, with significant variations for Globacom and Etisalat ($p<0.05$). The result further unraveled that, there was no statistically significant variation in the signal strength of Airtel and MTN networks ($p>0.05$) along the waterway, contrary to Globacom and Etisalat networks. The study hereby recommends that, navigators as well as customers using this waterway should prioritize Airtel sim card during voyage.

Keywords: Security, GSM, Signal Strength, Signal Quality and Waterway.

INTRODUCTION

The Oron-Calabar waterway is part of the Cross River Estuary, which is the biggest estuary in the Bight of Bonny (Nwosu, 2005). The Cross River estuary is fed by three main rivers, namely; Cross River, Great Kwa and the Akpa Yafe Rivers (Figure 1). The mangrove ecosystem associated with this estuary is least impacted in terms of anthropogenic

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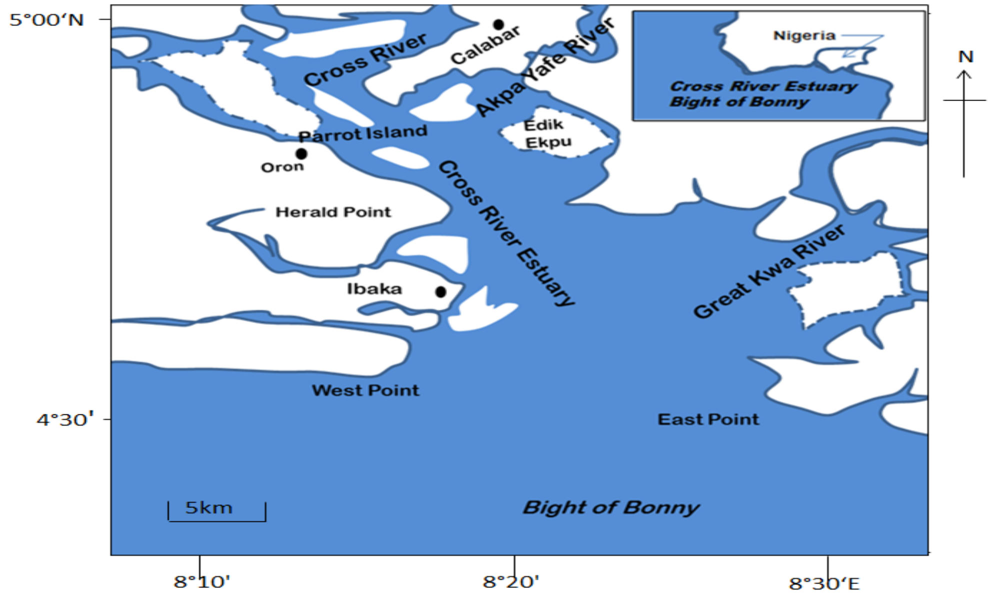

Figure 1. Map of Cross River Estuary showing Cross River, Great Kwa River and Akpa Yafe River.

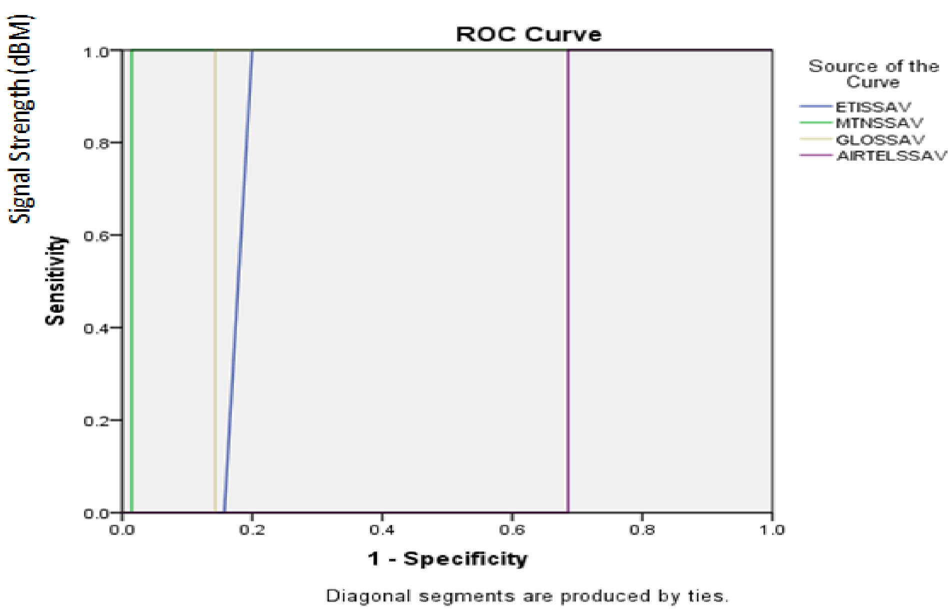

Figure 2. Receiver operating characteristic diagonal lines for GSM signal strength.

activities within the Niger Delta region. However, the Oron-Calabar waterway had been a major waterborne route for transporting of slaves during the slave trade era. Today, it is the cheapest route for the transportation of passengers and goods as well as agricultural products between Akwa Ibom and Cross River States. The Oron-Calabar waterway also provide access route to other countries such as Cameroon.

The deplorable state of feeder road networks into Akwa Ibom State (including the Calabar-Itu highway), opulent sand for dredgers and the position of the Parrot Island (a major fishing settlement among other fishing settlements in the Cross River estuary) along this waterway have given preference to this waterway by mariners, merchants as well as other travellers. Therefore, the Oron-Calabar waterway becomes one of the very busy water routes in the Gulf of Guinea. In recent times, navigators and passengers patronizing this waterway have lost their lives and goods to sea pirates operating within the Bight of Bonny (Gulf of Guinea). In addition, Essien and Adongoi (2015) reported on the increasing cases of piracy, sea robbery, illegal bunkering, unauthorized midstream discharges of goods and maritime militant activities are particularly prevalent in the waters and around the coast of the Niger Delta. The maritime militant activities ranges from pilfering and attacks on ship and offshore facilities and the hijacking of vessels for ransom notably in the Bayelsa waterways, Utawa – Opobo, Opobo- Andoni and Oron-Calabar waterways of Rivers and Akwa Ibom States (Essien and Adongoi, 2015). Efforts, been made by security agencies to stop the activities of pirates and maritime militant have not be very rewarding for lack of prompt communication with the rescue team about impending attacks on the victims or other security concerns.

The advent of GSM in Nigeria has brought telecommunication services nearer to an average Nigerian (Erik et al., 2011). A good quality GSM service could adequately supplement for the absence of GMDSS in vessels to aid appropriate waterborne communication. However, GSM signals become attenuated due to penetration loss as they pass through media not transparent to electromagnetic wave. Some of the media capable of attenuating GSM signal are: trees, water bodies, buildings, rocks, climate changes, free space, human activities, refraction and diffraction of the GSM signals (Okamoto et al., 2009; Elechi and Otasowie, 2002; Berlo, 2009; Sajal, 2010). Several studies (Okamoto et al., 2009; Shalangwa and Singh, 2011; Elechi and Otasowie, 2015) had been conducted on monitoring and evaluation of GSM signal strength ashore, but there has not been any known published work on GSM signal analysis along waterways (especially along Oron-Calabar waterway). GSM network in Nigeria is generally dissatisfying and frustrating in terms of quality of services. This is evidenced by the frequent call distortions, calls dropped, poor network interconnectivity, network congestion and echoes experienced during calls. It is in the light of the frustrating services by GSM network, which varies with network providers and locations, that this work investigates the strength and quality of cellular network variability along the Oron-Calabar waterway, in order to identify significant network(s) in the study area.

MATERIALS AND METHODS

The study used GSM network cell information Lite monitor version 3.12.5 APK for android (Plate 1). GSM network cell information lite monitor has several indicators including Received Signal Strength Indicator (RSSI), which measures the power present in a received radio signal. Most mobile devices use a set of bars of increasing height to display the approximate strength of this received signal to the mobile phone user (Forouzan, 2007; Sajal, 2010; Freeman, 2013). The signal quality was determined at Arbitrary Strength Unit (ASU) for the commonly used GSM networks (Etisalat, Globacom, MTN and Airtel) in Oron, Akwa Ibom State and Calabar in Cross River State. A speed boat was used to transport crew and equipment during field work, which lasted for four (4) days. The signal strength and signal quality for each network used in the study were obtained at 1hour interval starting from Oron. Three sets of data were collected for each GSM network per hour. Data obtained were inputted into the SPSS computer software for analysis.

Two android cell phones (GT850 Samsung Galaxy Alpha and A5 Samsung Galaxy) were deployed to install the GSM signal monitoring software. Four mobile SIM cards (Etisalat, Globacom, MTN and Airtel) were also installed in the phones. Stop watch was used during the signal survey to measure time interval in hours and data were collected at intervals of 1hour.

The Received Signal Strength Indicator (RSSI) recorded the signal strength in decibel milliwatts(dBm), which by standards is always a

Plate 1. GSM signal monitoring screen (Amaefule, 2005).

negative value. The higher the negative value, the weaker the signal strength dBm. This is because '0' is the maximum power an electronic piece can read or transmit during communication. The power in dBM is described in terms of 10x the logarithm of the actual power per milliwatts. The dBM can be expressed in terms of power as shown below;

P(dBm) = Power expressed in dBm
P(W) = The absolute power in watts
mW = Milliwatts
Log_{10} = Log to base 10

The data obtained were inputted into the computer software (SPSS) for analysis. The average values for signal strength and signal quality for each network service provider (Etisalat, Globacom, MTN and Airtel) were evaluated. Their mean values were compared using one way Analysis of Variance (ANOVA) to determine the network variability along the waterway.

RESULTS AND DISCUSSION

Table 1 is the result obtained from one way Analysis of Variance (ANOVA), which was used to compare the mean values of signal strengths for the four networks (Etisalat, Globacom, MTN and Airtel) used in this study. The table indicates that, Airtel has the maximum signal strength with a mean value of -93.00, closely followed by Etisalat with mean value of -95.00, Globacom with mean of -101.68 and MTN with mean value of -103.06.

The data obtained for the signal strength were used to use to plot the receiver operating characteristic diagonal lines (Figure 2), a two dimensional measure of the classification performance of the four GSM networks. The receiver operating characteristic diagonal lines is a scalar, which evaluates mono-facet of performance of the four cellular networks used for the study. The receiver operating characteristic diagonal lines for the signal strengths inferred that, the signal strength for Airtel network was strongest of the four networks considered for the study area, while the weakest signal strength in the waterway studied was the MTN. Andrew et al. (2007) and Camarillo (2004) identified channel reuse, signal limit factor, cellular multipath fading and radio power attenuation as some of the problems associated weak GSM signal strength in any location.

The variability in network signal strength for Airtel was not statistically significant as $p>0.05$, while that of Etisalat was statistically significant as $p<0.05$. This shows that, the strength of Etisalat network fluctuates significantly along the waterway. It is therefore considered not good for distress communication. However, the signal strength for Globacom and MTN networks yield higher negative

Table 1. ANOVA Result for GSM Network signal strength.

GSM Network	N	$\bar{X}$	SD	DF	SS	MS	Sig.
Etisalat	71	-95.00	11.74	70	9651.99	137.9	0.000
MTN	71	-103.06	13.15	70	12103.78	172.9	0.130
Globacom	71	-101.68	17.42	70	21251.99	303.6	0.010
Airtel	71	-93.00	11.78	70	9716.22	138.8	0.201
Total	284	-392.74	54.09				

Significant at p<0.05.

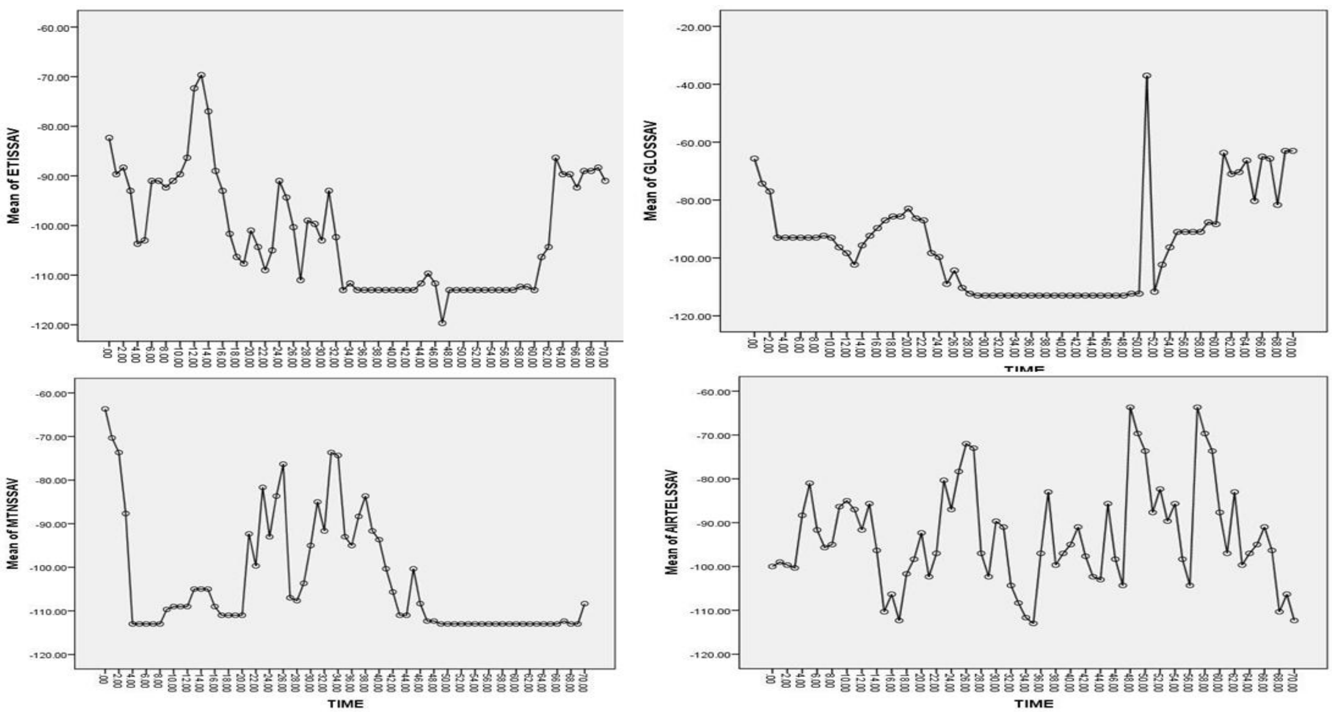

Figure 3. GSM signal strength variability over the Oron-Calabar waterway.

values. These high negative values were interpreted as weak signal strength. Nigeria Communication Commission (NCC) (2005); David and Pramod (2005); Boulmalf and Akhtar, (2007); Adegoke et al. (2008); Emeruwa (2014) and Umoh et al. (2014) noted that weak signal strength can in no way sustain calls therefore, customers will experience calls drop, calls distortion, echo and poor communication. Figure 3 is a plot showing the extent of GSM signal strength variability in the study area.

The result on the ANOVA for signal quality analyzed for the four networks (Etisalatu, MTN, Globacom, and Airtel) is contained in Table 2. Airtel had the best signal quality with the mean value of 10.05, closely followed by Globacom with mean value of 8.47, Etisalat with mean 5.98 and MTN with mean of 5.52 in that order. This order is represented in the receiver operating characteristic diagonal lines for network quality studied (Figure 4). The variability in quality for the various networks quality was analyzed.

Result shows that the variability in Airtel network quality as well as MTN network along the waterway

Table 2. ANOVA Result for GSM Signal Quality.

GSM network	N	$\bar{X}$	SD	DF	SS	MS	Sig.
Etisalat	71	5.98	6.07	70	2578.86	36.84	0.000
MTN	71	5.52	6.49	70	2943.94	42.06	0.781
Globacom	71	8.47	8.25	70	4795.02	68.50	0.012
Airtel	71	10.05	5.90	70	2440.29	34.86	0.881
Total	284	30.02	26.71				

Significant at p<0.05.

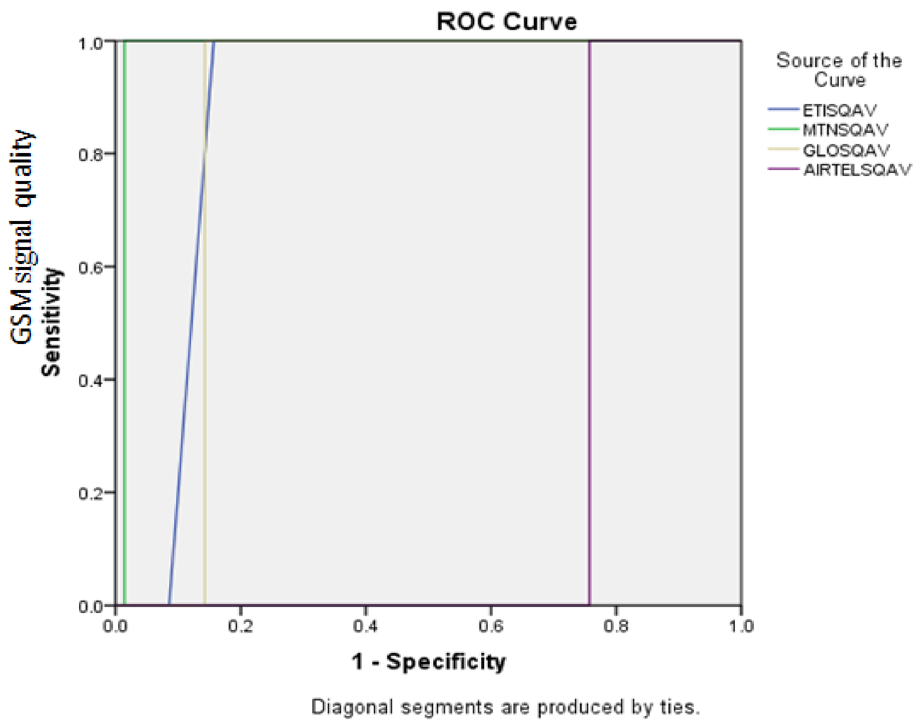

Figure 4. The receiver operating characteristic diagonal lines for GSM Signal quality.

was not statistically significant as p>0.05. This implies that the signal quality for Airtel and MTN networks were fairly distributed along Oron-Calabar waterway, with insignificant fluctuations in quality. On the contrary, variability in quality of Etisalat and Globacom networks show statistically significant values (as p<0.05) along the waterway. The implication is that, these networks quality fluctuations will be high along the waterway. Figure 5 is the graphical representation of signal quality fluctuations for the cellular network studied. The graph also show that for Globacom and Etisalat networks, the signal qualities remain at the ground state for hours towards the Calabar end of the waterway.

The study further reveals that, there were areas where network services cannot cover effectively by the nearby base station, or repeater. These areas are technically considered to be the "dead zones". According to Elechi and Otasowie, (2015); Raivio

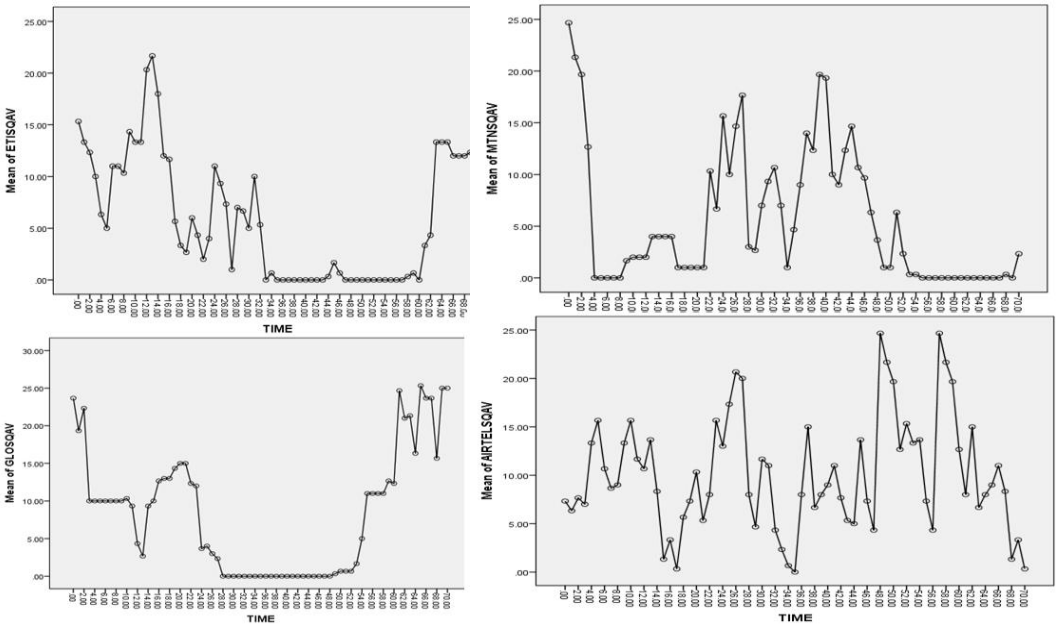

Figure 5. GSM signal quality variability over the Oron-Calabar waterway.

and Lehtimaki, (2006) a dead zone occurs when the signal between the handset and mobile site antennas is blocked or severely reduced by obstacles usually by hilly terrain, dense creek, distance, limited network density, interference with other mobile sites, topography and weather conditions. Because cell phones rely on radio waves, which travel through the air and are easily attenuated (particularly at higher frequencies), GSM signal strength and quality may become very unreliable as observed in the study especially for such networks as Etisalat, Globacom and MTN. This is based on the fact that the effectiveness of any cellular call is a function of the signal strength and quality. Therefore, there is a need for continual improvement and upgrade of network boasters in order to minimize dropped calls, access failures, and dead zones if the safety of life and properties of customers patronizing the Oron-Calabar waterway are to be guaranteed.

CONCLUSIONS

Based on results obtained for the study, cellular network signal strength was good for Airtel and Etisalat networks. However, the signal quality for Etisalat network was considered low with notable significant levels of signal fluctuation observed in the study area. Airtel network indicated the best in terms of signal strength and quality. Globacom and MTN network had the worst signals in terms of strength and quality. Therefore, of the four networks used for the study, Airtel network was regarded as the most reliable network in the study area. The study shows that, Airtel network would experience minimal call drops, network outage and call distortions along the waterway, closely followed by Etisalat, Globacom and MTN. However, the maximum call drop, network outage and call distortions would be experienced by MTN network. Therefore, the Etisalat and MTN networks need to be boosted by installations of relevant facilities needed to enhance the strength and quality of the cellular network signals along the waterway. The results obtained for this study was supported by the number of bars on cell phones for GSM subscribers within Oron and Calabar towns. The work recommends that, navigators, merchants and passengers patronizing the Oron-Calabar waterway should prioritize Airtel sim-cards for effective communication during voyage along the waterway. In addition, other network providers should boost their signal by installing facilities at strategic locations that would boost the strength and qualities of GSM signal along the waterway.

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