Australian Journal of Basic and Applied Sciences, 7(7): 35-42, 2013
ISSN 1991-8178

Application of Amplitude Modulated Medium Wave Transmitters in Deploying Advanced Traveller Information System

[1]Adenodi, R.A., [2]Ajewole, M.O., [2]Ogolo, E.O and [2,3]Adediji, A.T.

[1]Department of Physics, Adeyemi College of Education, Ondo. Ondo State, Nigeria
[2]Department of Physics, The Federal University of Technology, Akure. Ondo State, Nigeria.
[3]Department of Electrical, Electronics and Systems Engineering, Faculty of Engineering and Built Environment, University Kebangsaan Malaysia.

Abstract: This study is focused on the assessment of the coverage areas of some AM-MW transmitters over the landmass of owner states as well as investigating the usability of the MW frequency band in deploying the Advanced Traveller Information System (ATIS) of the Intelligent Transport System (ITS) in Nigeria. Electric field strengths of two MW transmitters; the Federal Radio Corporation of Nigeria (FRCN), Kaduna, Kaduna State and the Broadcasting Corporation of Oyo State (BCOS), Ibadan, Oyo State were measured along some routes around the transmitters during the rainy and dry seasons. The results were interpolated to generate primary, secondary and fringe coverage areas which were geo-referenced on the maps of the owner states. The seasonal variation in the coverage areas were deduced and possible location of radio beacons for full ATIS coverage of the state were predicted. The study reveals that signals from digital transmitter provide wider coverage area than signals from analogue transmitter of the same transmitter power. Therefore, digitizing the existing analogue AM-MW system will enhance good coverage and therefore can be used effectively for road traffic navigation in Nigeria.

Key words: Amplitude Modulation, Coverage Areas, Electric Field Strength, Radio Beacon, Booster Station.

INTRODUCTION

Radio transmission is a way of reaching large number of people and communities within a short time without the use of cables. It is faster and more convenient than the print media. Its applications include; radio broadcasting, remote sensing, road traffic navigation, and so on. Nigerians depend much on the radio broadcasting stations for regular updates of happenings within and outside the nation. Over the decade, other means such as broadcasting through the frequency modulated signals (FM), use of the internet had increased tremendously, thus leading to the decline in the number of amplitude modulated medium wave (AM-MW) transmitters in Nigeria. The decline could be adduced to the noise inherent in its signals compared to that of FM. Though, FM radio signals have wider coverage in the day time compared to analogue AM-MW signals, the signals skip some places within the coverage area. Their coverage often extends over states with different cultures; therefore, local programmes/dialects of owner state are not received by a vast number of listeners within the state; that is, through FM broadcasting, information does not really get to the grassroots. Broadcasting through AM-MW radio provides covert coverage such that no place is skipped within the coverage area and local dialects are involved, hence, every individual become acquitted with happenings in the community/state. Some FM radio stations are involved in broadcasting road traffic conditions to listeners for a period of twenty to thirty minutes between 8 and 9 am in some days within the week. This is because traffic congestion is a major problem in many Nigerian cities (Cliff, 2002; Aderamo and Atomode, 2011; Chibuzor 2011). It occurs in forms of recurrent queue of vehicles, delays and time wasting which sometimes leads to spoilage of freight and increased cost when road network is unable to accommodate the volume of traffic using it. This is due to rapid growth in population and motorization with no corresponding improvement in road network, land-use planning and traffic management techniques (Fadare and Ayantoyinbo, 2010). The time dedicated to broadcasting road traffic conditions to motorists are grossly inadequate and this does not give room to listeners to know the happenings along other roads except those mentioned by the broadcasters. Global Positioning Systems (GPS) based road navigation give opportunity for road users to check all the possible routes to their destination and then make choice based on vehicle free-flow and travel time. Errors associated with GPS measurement are satellite ephemeral prediction error, ionospheric and tropospheric delay errors and artificial error induced by selective availability technique. Differential Global Positioning Systems (DGPS) is an enhancement of the GPS, through the use of differential corrections to the basic satellite measurements performed within the user's receiver (ITU-R, 1995). The differential is based on accurate knowledge of the geographic location of a reference station, which is used to compute corrections to GPS parameters and the resultant position solution. The differential correction is then transmitted to GPS users. Differential correction

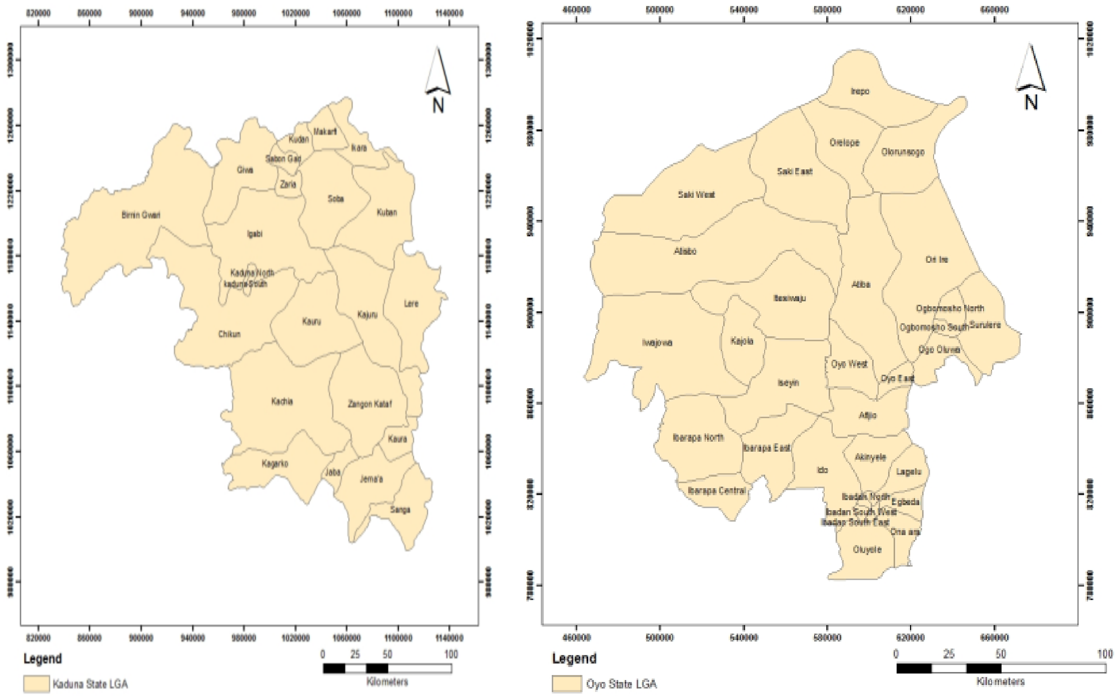
Corresponding Author: Adenodi, R.A, Department of Physics, Adeyemi College of Education, Ondo. Ondo State, Nigeria
E-mail: adenodiraph@gmail.com, +2340804425682

can be done in real – time or post process. The DGPS consists of a reference station, a control station and a radio beacon (Ketchum *et al*., 1997). In DGPS, the greater the distance of the GPS receiver from the radio beacon, the greater the position error incurred. Therefore the distance can be reduced by providing radio beacons in the proximity of users. The control station remotely monitors and controls the DGPS via data communication links. It monitors the three elements of DGPS performance which are accuracy, availability and integrity. Accuracy is the degree of conformance between the measured position, velocity and time of a GPS receiver and its true position, velocity and time. DGPS increases the accuracy of GPS data. Availability is the percentage of time in a month period during which the DGPS transmits healthy correction signal at the specified output level. Usually, the DGPS is designed to maintain availability level of 99.7% assuming a complete and healthy satellite constellation. Integrity is the ability of the DGPS to provide timely warnings to users when the system should not be used for navigation as a result of error or failures in the system. Advanced traveller information system involves informing motorists about the road conditions through a system of real-time in-vehicle GPS navigation system. This provides the fastest path between a current location and final destination. The road user is able to consider in real time, recurring and non-recurring congestion, select alternative route, mode and time of travelling as well as event location (Levinson, 2003). Google maps on GPS show roads in red, yellow and green based on the level of reduced congestion and free-flow of vehicles (Roy *et al*, 2011). This reduces cost and environmental pollution, travel time; enhance economics and the effectiveness of incidence management. Therefore the AM-MW transmitters can be converted to radio beacons for surface traffic navigation through advanced traveller information system technique. This study is aimed at assessing the coverage areas of some transmitters over the landmass of owner states as well as investigating the usability of the MW frequency band in deploying the Advanced Traveller Information System (ATIS) in Nigeria.

MATERIALS AND METHODS

This study is focused on two transmitters; the Federal Radio Corporation of Nigeria (FRCN) digital transmitter located in Jaji, Igabi local government area (LGA) of Kaduna State (fig. 1a) and the Broadcasting Corporation of Oyo State (BCOS) analogue transmitter located in Ibadan, Ibadan North LGA of Oyo State (fig. 1b). Kaduna State is located in the Northern part of Nigeria and is made up of 23 LGAs while Oyo State is located in South Western part of Nigeria and is made up of 33 LGAs. The instruments used for the study are Potomac field strength meter FIM – 21, Garmin 38 Global Positioning System (GPS), HP mini laptop and a hard copy of the map of Nigeria. The field strength meter is a radio receiver equipped with an antenna placed within an unknown field and readout for displaying the measured voltage. The field strength meter was used to measure the electric field strength along some routes around the transmitters. The GPS registered the coordinates of the points of measurements along the routes (Lima *et al*, 2007; Guerra *et al*., 2006). The coverage areas were contoured with the aid of Surfer software and geo-referenced on maps by arcview. Along each route, the point of measurement ranges from 5-10 km so that rapid change in the contours of electric field strengths can be recognized. This is important in identifying regions where change in electric field strength is caused by a change in the ground electrical conductivity (Makki et. al., 2008). The measurements were taken between the hours of 9:00 am and 5:00 pm to avoid measuring the electric field strength of space wave. Since the value of ground electrical conductivity is related to wetness of the ground (Wraith *et al*., 2005) and consequently that of electric field strength, the measurements were done during wet and dry seasons. The electric field strengths were measured along some routes leading away from the transmitter. The electric field at distances very close to the antenna were not measured since measurement of the field at such distances are not affected by natural ground conductivity and also the effect of signal dissipation depends on the distance travelled away from the transmitter (Fano and Escriva, 2008). The FULL SCALE of the field strength meter has six selectable maximum possible values which are: 100 µV, 1 mV, 10mV, 100mV, 1 V and 10 V. The calibration on the panel meter ranges from 1 to 10. The GPS receiver collects the signals transmitted from a system of 24 orbiting radio-navigation satellites. Table 1 gives the parameters of the transmitters of FRCN and BCOS whose signals were assessed. The field strength meter was mounted on a car with a height not far from the ground surface. After collecting data, the coordinates of points of measurements were converted to universal transverse mercator (UTM) projection system useful in the softwares used in this study (Barbara, 2007). An interpolation technique known as Kriging was adopted for contouring the coverage areas of the transmitters. Kriging calculates weights for sampled locations in deriving predicted values for unsampled locations. It is based on the methods of geostatistics and has proven useful and popular in many other fields (Konak, 2010). The electric field was contoured into primary, secondary and fringe coverage areas with values of 1, 0.5 and 0.25 mV/m adopted from Ajayi and Owolabi (1975). In arcview, the surface area of a polygon of the contour can be calculated by using the field calculator (Jeason, 2009). This is done by clicking along the perimeter of the polygon after selecting the field area calculator and the desired unit of measurement. The surface areas of primary, secondary and fringe coverage areas were imported in shape file format into arcview and the surface areas were thus calculated.

Based on the coverage area of the transmitters, locations were predicted for radio beacons for full coverage of the states for in-vehicle GPS navigation system.



(a) Kaduna State (b) Oyo state

Fig. 1: Maps of Kaduna and Oyo States in Nigeria.

Table 1: Parameters of OYO Radio and FRCN KadunaTransmitters

Parameters	OYO Radio	FRCN Kaduna
Transmitter Power	50 kW	50 kW
Frequency	756 kHz	594 kHz
Height of Mast	137.16 m	126.0 m
Coordinates of location	Latitude 7° 24' 35.10"N Longitude 3° 55' 57.70" E Altitude 282.0 m	Latitude 10° 49'13.90"N Longitude 7° 33' 58.90"E Altitude 662.0 m
Name of location	Orita Basorun, Ibadan North LGA, Oyo State	Jaji, Igabi LGA, Kaduna State.
UTM Zones	31	32

RESULTS AND DISCUSSION

FRCN Kaduna Transmitter:

This station is the only AM-MW that transmits digital signals in Nigeria. The electric field strengths were measured along eight routes starting from the transmitter. Some of the routes assessed overlapped because there are no direct routes to the various LGAs except through some major roads. The routes are predominantly within Kaduna State but few lengths of two routes ended in Funtua LGA of Katsina State and Bebeji LGA in Kano State. In Kaduna State the routes traversed Igabi, Kaduna North, Kaduna South, Chikun, Kachia, Birnin Gwari, Zaria, Sabon Gari, Giwa, Kudan, Makarfi, Soba, Kajuru, Kudan, Kauru and Karia LGAs. About 24 LGAs were covered in three States. The transmitter is fairly centrally located within Kaduna State but the coverage is considerably large because the station uses a digital transmitter of high fidelity; hence its signals are capable of larger coverage area at reduced radio noise level.

The coverage areas of the transmitter in the wet season are presented in figure 2. The primary coverage area in wet season is about 11,678.16 square kilometres which covered the whole of Igabi, Kaduna North, Kaduna South, Zaria, Sabon Gari LGAs in Kaduna State, some portions of Kudan, Makarfi, Kauru, Chikun, Kachia, Giwa LGAs in Kaduna State, and Danja and Sabuwa LGAs in Katsina State. The secondary coverage areas covered 5,088.92 square kilometres landmass which include part of Kauru, Kanjuru, Kuban, Ikara, Makarfi, Chikun and Birnin Gwari LGAs in Kaduna State, Shiroro LGA in Niger State, Sabuwa, Danduma, Funtua, Danja, Bankori and Kafur LGAs in Katsina State and Rogo LGA in Kano State. The fringe coverage area covered 5,248.13 square kilometres of landmass which include portions of Chikun, Kachia, Kauru, Kanjuru, Kuban, Ikara, Makarfi and Birnin Gwari LGAs in Kaduna State, Shiroro LGA in Niger State, Sabuwa, Dandume, Funtua, Bankori, Danja and Kafur LGAs in Katsina State, Rogo and Kiru LGAs in Kano State.

The coverage area during the dry season is shown in figure 3. The primary coverage area is about 11,444.83 square kilometres of landmass which include the whole of Giwa, Igabi, Kaduna North, Kaduna South, Zaria, Sabon Gari, and part of Soba, Kudan, Giwa, Kauru, Makarfi, Birnin Gwari, Kanjuru and Kuban LGAs in Kaduna State, Sabuwa, Dandume, Funtua and Danja LGAs in Katsina State. The secondary coverage area covered 4,600.60 square kilometres of landmass which includes some portion of Chikun, Birnin Gwari, Kauru, Kanjuru, Soba, Kuban, Ikara, Makarfi, Kudan and Giwa LGAs in Kaduna State, Sabuwa, Dandume, Funtua, Danja, Bankori and Kafur LGAs in Katsina State and Rogo LGA in Kano State. Table 2 gives the summary of the coverage during wet season are and the dry season.

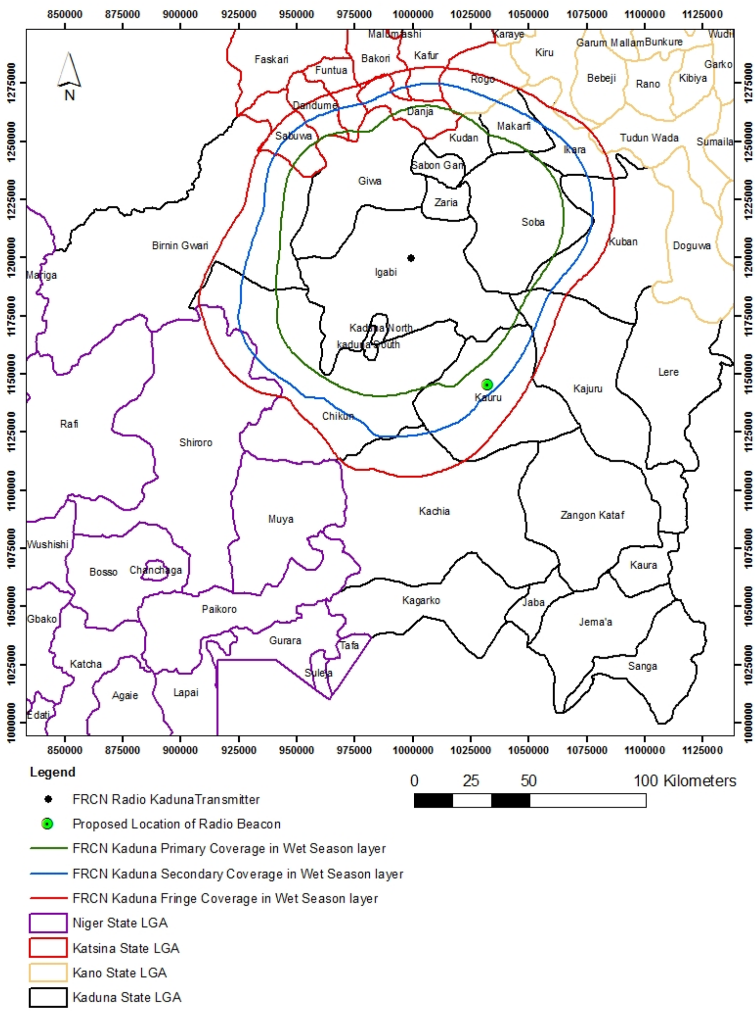


Fig. 2: Coverage Areas in Wet Season and Location of Radio Beacon

Table 2: Summary of the Coverage Areas of FRCN transmitter in both Seasons

Service area	Wet Season	Dry Season	Difference
Primary service area (km^2)	11,678.16	11,444.83	233.33 (2.05%)
Secondary service area (km^2)	5,088.92	4,600.60	488.32 (9.66%)
Fringe service area (km^2)	5,248.13	4,516.05	732.08 (13.70%)
Total coverage area (km^2)	22,015.21	20,561.48	1,453.73 (6.60%)
Area of useful service (km^2)	16,767.08	16,045.43	721.65 (4.30%)

OYO Ibadan Radio Transmitter:

The electric field strengths were measured along seven routes starting from the transmitter to regions where the signals could no longer be detected. The routes are through Oyo, Osun and Ogun States because the transmitter is located close to the state boundary in Ibadan North LGA at the southeast edge of Oyo State. In Oyo State the routes traversed Ido, Ibarapa East, Iseyin, Akinyele, Afijio, Oyo East, Ogbomoso, Lagelu, Egbeda, Oluyole and Ibadan South LGAs. In Osun State the route traversed Iwo, Olaoluwa, Ede North, Irewole and Ife North LGAs. The routes also cut through Ijebu North, Ijebu Ode, Remo North, Ikenne, Sagamu, Odeda, Abeokuta South and Abeokuta North LGAs of Ogun State. About 25 LGAs were covered in the three states. If the transmitter was centrally located within Oyo State, many of the LGAs would have been covered by the signals.

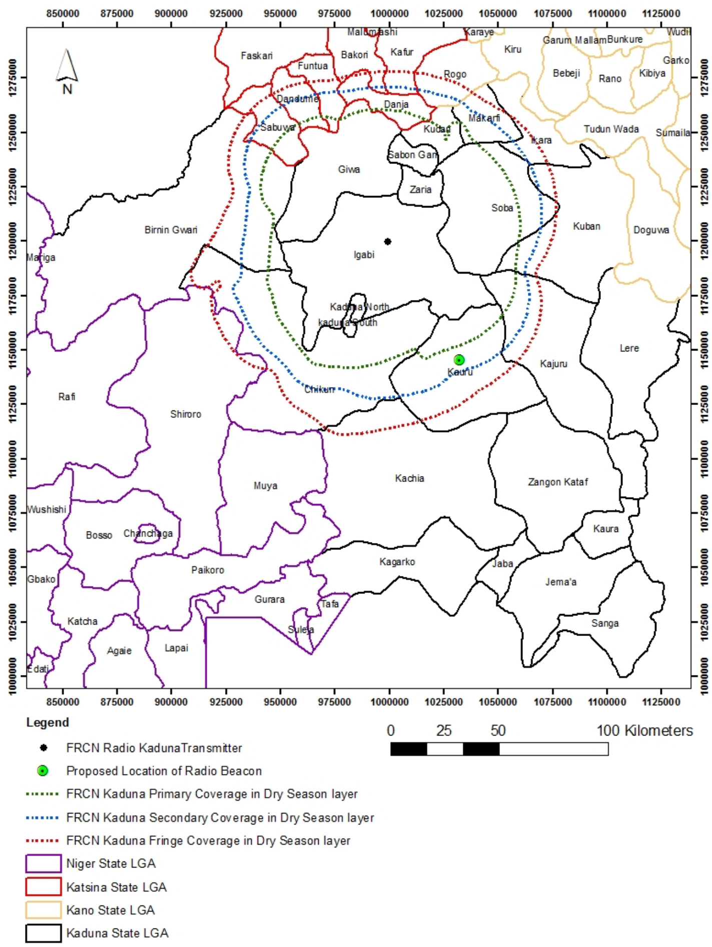


Fig. 3: Coverage Areas in Dry Season and Location of Radio Beacon

Figure 4 shows the coverage areas of the transmitter in wet season. Primary, secondary and fringe coverage areas are shown in yellow, blue and red colours respectively. The primary service extends over about 7,163.06 square kilometres, which includes Akinyele, Afijio, Lagelu, Ona Ara, Egbeda, Ibadan North, Ibadan Southwest, Oluyole and Ido LGAs in Oyo State, Olaoluwa, Iwo, Aiyedire, Irewole, Aiyedade and Isokan LGAs in Osun State and Odeda LGA in Ogun State. The secondary service area covers an area of about 3,646.35 square kilometres, which includes part of the following LGAs; Ibarapa East, Iseyin, Oyo West and Oyo East in Oyo State, Ejigbo and Ife North in Osun State and Ijebu East, Ijebu North, Remo North, Obafemi Owode, and Odeda and Ikenne in Ogun State. The fringe service area is about 3,418.49 square kilometres, which includes part of the following LGAs in Oyo State: Ibarapa East, Iseyin, Atiba, Ori Ile and Ogo Oluwa; Ejigbo, Egbedore, Orolu, Ede North, Ede South, Atakunmasa West, Ife East, Ife South, Ife North, Ife Central LGAs in Osun State; Ijebu East, Ijebu North, Ikenne, Obafemi Owode, Abeokuta South, Odeda, Ibarapa Central LGAs in Ogun State. The total area covered by the signal is 14,227.90 square kilometres but the signals' usefulness can only be guaranteed over 10,809.41 square kilometres. If the transmitter was centrally located within Oyo State, many of the LGAs would have been covered and about a single booster station will be required for a full coverage of the state since the service coverage of the transmitter is below the surface area of the landmass of Oyo State which is about 28,454 square kilometres. In its present condition, about two booster stations are needed for a full coverage of the state. The proposed locations of the radio beacons shown in both figure 4 is Aluko and Otun in Iseyin and Itesiwaju LGA respectively. The transmitter was originally established to cover the old southwest region. The inability of the transmitter to cover the south western states now is due to some factors which include a major increase in radio noise as a result of industrialization as well as development of new areas.

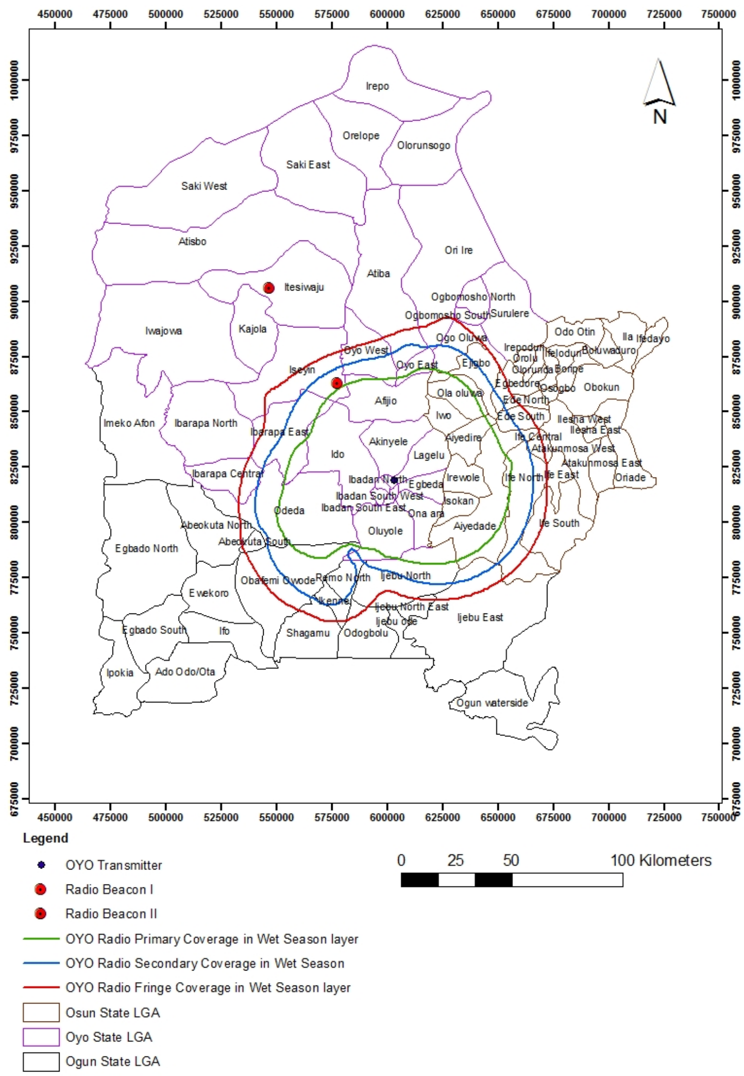


Fig. 4: Coverage Areas in Wet Season and Location of Radio Beacons

Table 3: Summary of the Coverage Areas of OYO transmitter in Wet and Dry Seasons

Service area	Wet	Dry	Difference
Primary service area (km^2)	7,163.06	4,019.95	3,143.11 (43.88%)
Secondary service area (km^2)	3,646.35	2,758.52	887.83 (24.35%)
Fringe service area (km^2)	3,418.49	3,438.23	19.74 (0.57%)*
Total coverage area (km^2)	14,227.90	10,189.64	4,038.26 (28.38%)
Area of useful service (km^2)	10,809.41	6,778.02	4,031.39 (37.30%)

*greater fringe service area

The coverage areas of the transmitter during the dry season are presented in figure 5. The primary service of the transmitter extends over an area of about 4,019.95 square kilometres which include the whole of Akinyele, Lagelu, Ona Ara, Egbeda, Ibadan North, Ibadan South West, Ibadan North West, Ibadan South East, Ibadan North East, some portions of Oluyole, Ido and Afijio LGAs in Oyo State, the whole of Isokan, Iwo and Irewole, Aiyedire and Aiyedade LGAs in Osun State and Ijebu North and Odeda LGAs in Ogun State. The secondary service area covers a total area of 2,758.52 square kilometres with 89.50 square kilometres located within the fringe service area which covered some places around the boundary of Oluyole LGA in Oyo State, Obafemi Owode and Remo North LGAs in Ogun State. The remaining 2,669.02 square kilometres which include part of Ibarapa East, Oluyole and Afijio LGAs in Oyo State, Iwo, Ola Oluwa, Aiyedire, Irewole and Aiyedade LGAs in Osun State, and Ijebu North and Odeda LGAs in Ogun State. The fringe service area covers a total area of about 3,438.23 square kilometres which includes Ibarapa East, Iseyin, Oyo West, Oyo East and Afijio LGAs in Oyo State, Ola Oluwa, Aiyedade and Ife North LGAs in Osun State and Ijebu East, Ijebu North East, Ijebu North, Remo North and Odeda LGAs in Ogun State. The total area covered by the signal is 10,189.64 square kilometre but the signal usefulness can be guaranteed only in about 6,778.02 square kilometres. The differences in the coverage areas are presented in table 3. The coverage in wet season are generally greater except that the fringe service in dry season is greater by 19.74 square kilometres.

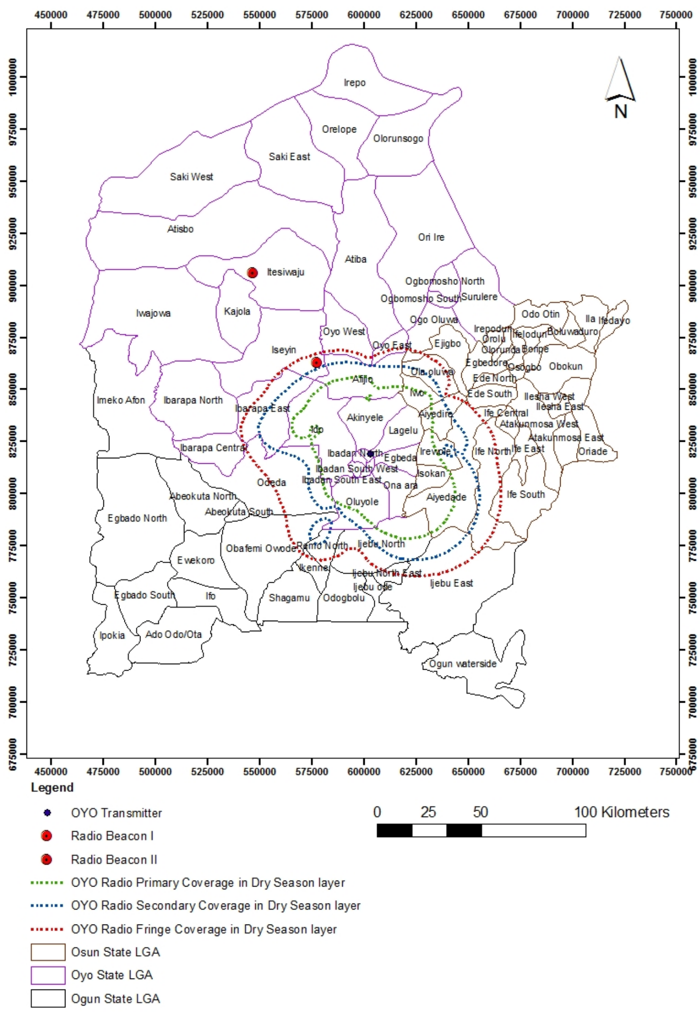


Fig. 5: Coverage Areas in Dry Season and Location of Radio Beacons

Conclusion:

This study was carried out to assess the coverage areas of some MF – AM transmitters in Nigeria. Measurements were made along some routes and electric field strengths measured and recorded were interpolated into contour of coverage areas. The coverage areas were compared in terms of seasons; wet and dry, types of transmitter; analogue and digital and location; semi savana and forest zones. The possible locations of radio beacons for full coverage of the landmass of the owners' states were suggested.

From the study therefore, it was deduced that digital transmitter provides larger coverage and the signals are less susceptible to noise. Therefore, the AM-MW analogue transmitters should be converted to digital rather than completely eliminates MF broadcasting in Nigeria. The digital AM transmitter will compete favourably with the FM transmitters. The digital transmitters will do well if converted to radio beacons for the purpose of deploying ATIS technique for road traffic navigation.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the Centre for Research in Instrumentation and Management (CRIM) of the Universiti Kebangsaan Malaysia for research award under the project code UKM-MI-OUP-2011 to one of them.

REFERENCES

Aderamo, J. Adekunle and Atomode I. Tolu, 2011. Traffic Congestion at Road Intersections in Ilorin, Nigeria. Australian Journal of Basic and Applied Sciences, 5(9): 1439-1448.

Ajayi, G.O. and I.E. Owolabi, 1975. Medium Wave Propagation Curve (for use in medium wave transmission planning and design). Technical Report of the Radio Wave Propagation Research Group, Department of Electrical Engineering University of Ife, Nigeria.

Barbara Parmenter, 2007b. Proximity Analysis – ArcGIS Functions Guide. Tuffs University.

Bauchi, F.M., Broadcasting through field measurements. Nigeria J. Pure and Applied Phys., 1: 28-32.

Chibuzor, Onyelowe Kennedy, 2011. Index Analysis of the Causes of Vehicular Traffic Congestion in South-Eastern Nigeria. Journal of Emerging Trends in Engineering and Applied Sciences, 2(6): 925-933.

Cliff, J., 2002. Roads and Traffic Congestion survey. Irish Business and employers.

Fadare, S.O. and B.B. Ayantoyinbo, 2010. A Study of the Effects of Road Traffic Congestion on Freight Movement in Lagos Metropolis. European Journal of Social Sciences, 16(3): 1-3.

Fano, W.G. and C. Grau Escriva, 2008. Near Field Characteristics of Monopole with a Parasitic. Prrogress in Electromagnetics Research letters, 5: 175-186.

Guerra, D., U. Gil, D. de la Vega, G. Prieto, A. Arrinda, J.L. Ordiales and P. Angueira, 2006. “Medium Wave Digital Radio Mondiale (DRM) Field Strength Time Variation in Different Reception Environments”, IEEE Transactions on Broadcasting, 52(4): 483 490.

ITU-R M.823-1, 1995. Technical Characteristics of Differential Transissions for Global Navigation Satellite Systems (GNSS) from Maritime Radio Beacons in the Frequency Band 283.5 – 315 kHz in Region 1and 285 – 325 kHz in Regions 2 and 3.

Jeason Ur, 2009. Introduction to ESRI Arcgis 9.3.1. Harvard University, China.

Ketchum L. Ronald, Lemmon J. John and Hoffman J. Randy, 1997. Site Selection Plan and Installation Guidelines for a Nationwide Differential GPS Service Institute for Telecommunication Sciences, The Federal Highways Administration, Department of Transportation. National Telecommunications and Information Administration Boulder, Colorado.

Konak, Abdullah, 2010. Estimating Path Loss in Wireless Local Area Networks using Ordinary kriging. Proceeding of the Winter Simulation Conference.

Levinson David, 2003. The value of advanced traveller information systems for route choice. Transportation Research Part C 11: 75-87.

Lima, F.F., H.A. Junior, A.J.M. Soares, L.M. da Silva, R.L. Filho and A.R. Baigorri, 2007. Statistical Modelling of the Mobile Radio Propagation in Rural Area at Medium Wave. Proceedings of ISAP2007, Niigata, Japan, pp: 177-180.

Makki, S.V., Al-Din, Erhadi and Pahlavani, 2008. Assessment of the Impacts due to the Alternation of Ground Conductivity over the Earth wave field Intensity in MW Band. Progress in Electromagnetics Research B, 4: 183-195.

Roy Swaroop, Sen Rijurekha, Kuilarni Swanand and Kuilarni Purushottam, 2011. Wire Across Road: RF based Road Traffic Congestion Detection. IEEE.

Wraith Jon M., A. Robinson David, B. Jones Scott and S. Long Dan, 2005. Spatially Characterizing Apparent Electrical Conductivity and Water Content of Surface Soils with Time Domain Reflectometry. Computers and Electronics in Agriculture, 46: 239-261.