

Measures that Enhance Favorable Levels of Service and their Modes of Sustainability on Major Roads in Akure, South-Western Nigeria.

AJAYI Samuel Akintomide
Nigerian Building and Road Research Institute
Ota, Nigeria.
samuel.temitope@ymail.com

OWOLABI Adebayo Oladipo
Department of Civil Engineering
Federal University of Technology
Akure, Nigeria

BUSARI Ayobami Adebola
Department of Civil Engineering
Covenant University
Ota, Nigeria

Abstract—Large cities in developing countries are characterized by a continuing growth in automobile ownership and insufficient transportation infrastructure and service development. The research provided information on the important parameters that engender various regimes of Levels of Service in Akure, Nigeria and brought out factors that enhance favorable Levels of Service and their modes of sustainability. This was achieved by collection of traffic metering parameters such as traffic composition and volume-capacity ratio; these were evaluated to determine the levels of services on the selected major roads such as Oke-Aro, Oke-Ijebu and Hospital which are critical in Akure metropolis. The traffic composition analysis revealed passenger car / taxi as the predominant mode for the entire route. Besides, the result also revealed increased volume of traffic, poor parking system, ribbon development/street trading, bad roads, poor geometric or operational constraints as factors affecting the level of service. Ultimately the result of this research will help transportation agencies and the government in proffering adequate measures for the reduction of traffic congestion on major roads in Akure and similar capital cities in Nigeria.

Keywords— traffic composition; level of service; traffic; volume-capacity ratio;

I. INTRODUCTION

Cities in developing countries are characterized by increasing growth in automobile ownership and insufficient transportation infrastructure to meet the demand. These cities most often suffer from congestion, poor mobility and accessibility, significant economic waste, adverse environmental impact and safety problems. Assessing the degree of congestion, should be a major task for developing countries transportation professionals. Congestion occurs when traffic demand approaches and exceeds highway/road capacity. To characterize congestion and other nature of traffic, it is necessary to determine the level of service.

According to [1]; road traffic congestion is one of the major indicators of a city socio-economic vibrancy. It has continually challenged the efforts of city and transport planners on the highways, the problems associated are longer travel time and delays over time and space. It has equally created an artificial barrier to a cost effective flow of goods and persons along our highways linking major towns together. The traffic conditions across highways in Nigeria are in a grim situation caused by daily congestion and daily accidents. "Reference [2] defined Level of Service (LOS) as a designated term used to qualitatively describe the operating conditions of a roadway based on parameters such as volume/capacity ratio, speed, travel time, maneuverability, delay, and safety. It designates six levels of service for each type of facility, from A to F, with LOS "A" representing the best conditions and LOS "F" the worst.

"Reference [3]; shed lighter on defining the operating conditions for these six levels of service selected by [2]:

A. Level of Service "A": Free flow, with low volume and high speed. Traffic density is low, with speed controlled by drivers' desired speed limits and physical roadway conditions. Individual users are virtually unaffected by others in the traffic stream; $v/c = 0.00$ to 0.60 .

B. Level of Service "B": represents the range of stable flow but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected but there is a slight decline in the freedom to manoeuvre within the traffic stream from LOS A; $v/c = 0.61$ to 0.70 .

C. Level of Service "C": represents the range of stable flow but the selection of speed is affected by the presence of others. Manoeuvring within the traffic stream requires substantial

vigilance on the part of the user, $v/c = 0.71$ to 0.80 . This is the target LOS for some urban and most rural highways.

D. Level of Service "D": Approaches unstable flow, with tolerable operation speed being maintained through considerably affected changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operation speeds. Drivers have little freedom to manoeuvre; comfort and convenience are low, but conditions can be tolerated for short periods of time. Minor incidents are expected to create delays, $v/c = 0.81$ to 0.90 .

E. Level of Service "E": unstable flow, operating at capacity, Cannot be describe by speed alone but represent operations at even lower operating speeds than in level D with volumes are or near the capacity of highway. At capacity speed are typical but not always in the neighborhood of 50 km/h. Flow is unstable, and there may be stoppage of momentary duration. Drivers' level of comfort becomes poor. Freedom to manoeuvre within the traffic stream is extremely difficult, $v/c = 0.91$ to 1.00 .

F. Level of Service "F": Forced flow operations at low speeds, where volumes are below capacity. Conditions result from queues of vehicles backing up from a restriction downstream. Speeds are reduced substantially and stoppage may occur for long or short period of time, because of downstream congestion. Travel time cannot be predicted, with generally more demand than capacity. A road in a constant traffic jam is at this LOS. In extreme, both speed and volume can drop to zero, v/c greater than 1.00

"Reference [4] discussed the need for Passenger car equivalence (PCE) to the traffic engineer both in the design of traffic facilities and also in the management of vehicles operations. Each vehicular types such as tricycle, motorcycles, car, buses, trucks/lorry in the traffic stream cannot be considered as equivalent to each other as there is significant difference in the vehicular and flow characteristics of each vehicle class. Therefore a Passenger Car Equivalent is majorly the impact that a mode of transport has on traffic variables (such as headway, speed, density) compared to a single car. Table I is the passenger car equivalents used to convert the traffic volume to passenger car unit per hour (pcu/hr) as given by [3].

Table I: Passenger Car Units (PCU)

Vehicle Type	Equivalent Passenger Car Units
Pedal Cycle, Tricycles and Motor Cycles	0.5
Motor-car, Station Wagon, Taxi, Kit-Car or Pick-up, Jeep, Land Rover, Light Delivery Van, Minibus	1
Trailer attached to above	2
2-Axle Truck Class, Lorry including Timber Lorry, Truck, Mammy Wagon, Petrol Tanker	2
Trailer attached to above	3
3 to 5 Axle Combination, Tractor Trailer including Low Loader, Petrol Tanker, Bus (Excluding Municipal)	3
Municipal Bus, More than 5 Axle Combination	4

"Reference [5] also worked on Akure Central business district to analyze traffic volume and revealed the cause of parking problem. From this study, increased volume of traffic, ribbon development /street trading, improper structural layout/land use pattern within the Central Business District (CBD) was factors responsible for these problems. Also the solution to the parking problem has been recommended via provision of adequate off-street parking facilities, abolition of all unauthorized terminals, adjustment of the structural layout /land use in the CBD and the provision of an inner ring road around the central business district.

Oyemekun Oba Adesida and Arakale are the major arterial in Akure metropolis, in order to ease traffic from these arterial, more roads were built by the Government such as Oke-Aro, Oke- Ijebu, Hospital, and Ondo roads. In recent time, these two-lane roads are often congested, resulting in poor mobility, reduced speed and, poor operating condition of service in terms of driver's freedom to maneuver, and delays at intersections. In order to proffer remedies, it is necessary to assess the operating conditions of service, characterize congestion and other nature of traffic and recommend design measures on these routes for the enhancement of free flow traffic, goods and persons. The aim of the research is to provide solution to the problem of traffic congestion on the selected major two-lane roads in Akure with the objectives of determining the nature of traffic such as volume/capacity ratio, and determine the levels of service of these routes. The result of this research will help transportation agencies and the government in proffering adequate measures for the reduction of traffic congestion on major roads in Akure and similar capital cities in Nigeria.

II DESCRIPTION OF THE STUDY AREA

The town Akure is the capital of Ondo State which is located within $7^{\circ} 15'$ north of the Equator and Longitude $5^{\circ} 05'$ east of the Greenwich Meridian. It covers approximately 340 square km, having a north- south length of 17 km and an east- west stretch of 20 km. According to [6], the area extent of Akure grew from 1937 ha in 1976 , to 5330 ha in 1986 (34.34%) and 7665 ha in 1996 (66.7%). The city has a population of $387,100$ according to 2006 census. This consisted of $175,495$ (49.68%) males and $177,716$ (50.32%) females who are mainly civil servants, traders and peasant farmer. The town has a good road network system, and the existing major road in Akure is dominated by the Oyemeku-Oba Adesida and Arakale roads with important transport facilities such as pedestrian walkways, bus stops, parking facilities, tarring of some feeder roads, erection of street and traffic lights.

"Fig 1" is the map of Ondo state while "Fig 2" is the detailed maps for selected major routes.

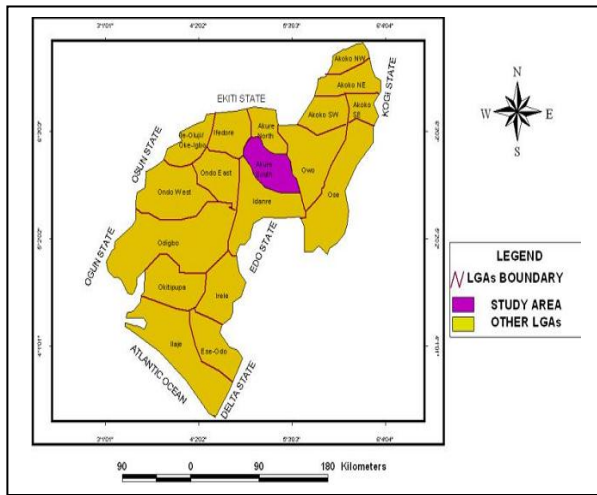


Fig. 1. Map of Ondo State, Nigeria.
Source: Ministry of Works and Housing

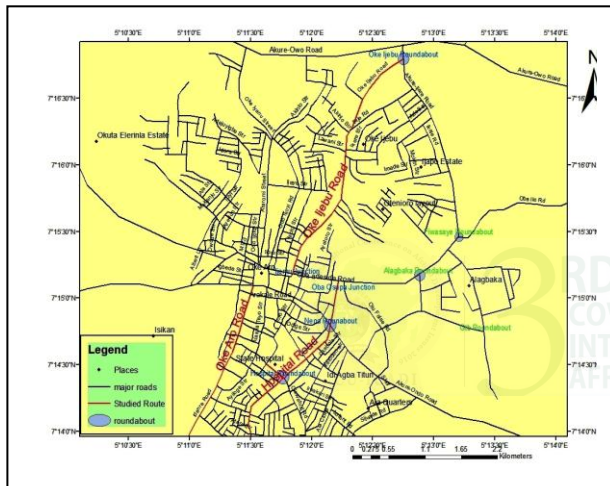


Fig. 2. Map of the Routes Selected for the Study
Source: Geographical Information System-2015

III. RESEARCH METHODOLOGY

The research covers three selected major roads:

- a. Hospital
- b. Oke – Ijebu
- c. Oke – Aro

These routes were selected because they are critical to the traffic flow in Akure Metropolis; they help in easing the traffic on the major arterials which are Oyemeku-Adesida and Arakale. A reconnaissance survey of the routes was conducted with a view to selecting possible routes and spots, which might be feasible and appropriate for data collection. These routes were divided for easy traffic data collection as shown in Table II.

Table II. Selected Routes segmentation

Route	Direction 1	Direction 2
Hospital I	Oba-Osupa junction to Nepa roundabout	Hospital junction to Nepa roundabout
Hospital II	Nepa roundabout to Hospital junction	Nepa roundabout to Oba-Osupa junction
Oke – Ijebu	Ijomu junction to Oke-Ijebu roundabout	Oke-Ijebu roundabout to Ijomu junction
Oke – Aro	Arakale Junction to Idanre Garage.	Idanre Garage to Arakale Junction

Traffic volume count was collected through a semi-automatic method that is by mounting digital video recorder on both directions on the roadway to take inventory for the morning, afternoon and evening peak periods. Data from the recorder were then decoded and transferred into recording sheets. A tally sheet was prepared, which contains the types of vehicles i.e motorcycle, cars, vans buses and trucks. These were arranged on the sheet in ascending order of their vehicular capacities. The tally sheet was marked as vehicles passed the reference point on the road. The traffic volume was converted to pcu/hr by multiplying each vehicle with their respective passenger car unit equivalents in order to get the approximate number of vehicles that ply all the selected roads during the chosen peak periods in terms of passenger car. These peak periods were between 7-9am, 12-2pm and 4-6pm for morning, afternoon and evening respectively on weekdays (monday – friday); 9-11am, 12-2pm on Saturdays; 7:30-9:30am and 12-2pm on Sundays.

As given by [2], the capacity for two-lane road is 2800 pcu/hr, therefore the Levels of service was determined by the analysis of volume-capacity ratio (v/c). A traffic projection for 10 years would result in Projected Traffic Volume using;

$$Q_n = Q_0 (1 + r)^n \tag{1} [7]$$

Q_n is the Projected Traffic Volume (pcu/hr)

r = Traffic Growth Rate (%)

n = Number of years for which projection is made;

Q_0 = Observed Maximum Traffic Volume.

Assuming a traffic growth rate of 3% as recommended by [8] for developing countries and substituting the values for known Observed Maximum Hourly Traffic Volume, the Maximum Projected Traffic Volume were obtained for each route. The future levels of service were determined from the ratio of maximum projected traffic volume and capacity.

IV. RESULTS AND DISCUSSION

A. Traffic Composition

“Fig. 3” is the traffic composition of vehicular types that ply Oke-Aro route. The chart revealed that the most predominant mode of transport in dir. 1 were passenger cars / taxi which constituted approximately 51% of traffic followed by motorcycles constituting of 46% and mini buses /vans, buses and trucks/lorries constituting 2.9% , 0.3% and 2.6% respectively. Also on dir. 2 motorcycles constituted 51% and

41% passenger car unlike dir. 1 while and mini buses /vans, buses and trucks/lorries constituting 4.2% , 0.2% and 3.8% respectively. The modal choice is affected by the type of trip which is mostly recreational, population, income of resident as given by [9]. The traffic prevalence of mini buses is low because of the prevalence of motorcycles and taxi to convey people to Idanre garage and out respectively.

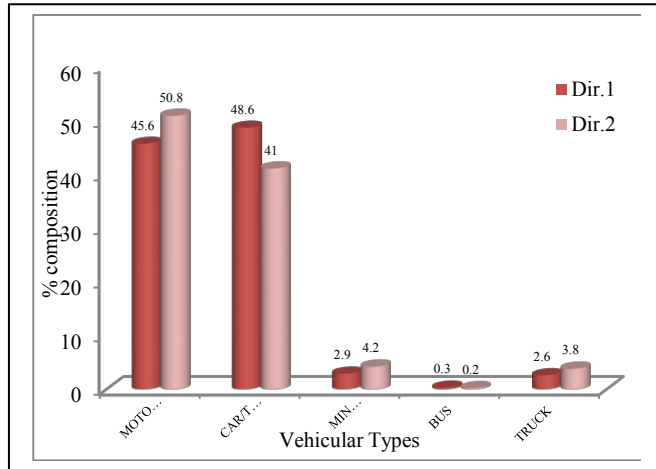


Fig. 3. Traffic Composition for the Week (Oke-Aro route)

Hospital routes: Also in fig. 4, passenger car / taxi have a greater percentage composition of approx. 64%, followed by Motorcycle: 30%, Mini Buses / Vans: 3.0%, Buses: 1.6% and Truck: 1.0% for dir. 1a. Likewise, passenger car is predominance of approx. 57%, followed by Motorcycle: 39%, Mini Buses / Vans: 2%, Buses: 1% and Truck : 1.6% in dir.2a.

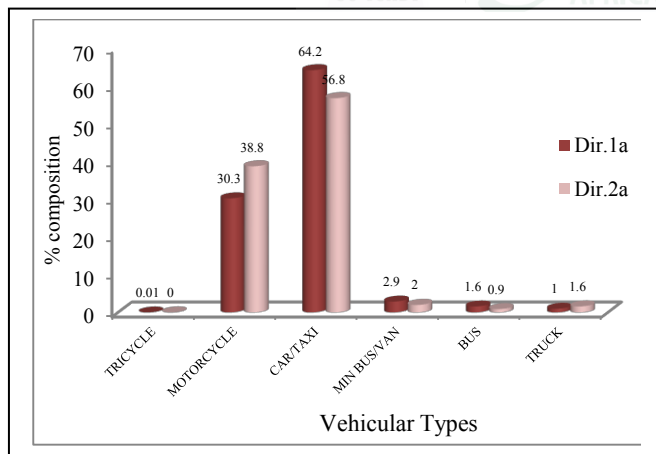


Fig. 4. Traffic Composition for the Week (Hospital I)

For Hospital II, passenger car has a greater percentage composition of approx. 61%, followed by Motorcycle: 36%, Mini Buses / Vans: 1.5%, Buses: 1% and Truck: 0.8% in dir.1b. Also for Dir. 2b, passenger car has a greater percentage composition also in this direction of approx. 61%, followed by Motorcycle: 35%, Mini Buses / Vans: 1.8%, Buses: 1% and Truck: 0.7%. This is shown in fig. 5.

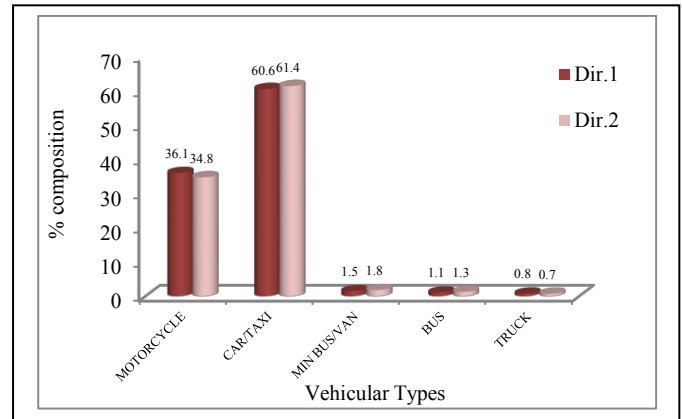


Fig. 5. Traffic Composition for the Week (Hospital road II)

The dominance of passenger car / taxi in Oke-Ijebu is shown in fig. 6 with the highest composition of approximately 50% and 53% for dir. 1 and 2 respectively followed by motorcycles. The dominance of taxi affected the volume /traffic build up / congestion on this route.

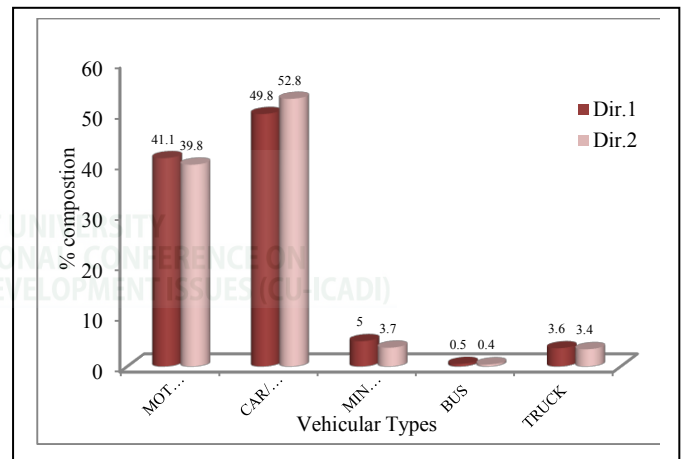


Fig. 6. Traffic Composition for the Week (Oke-Ijebu)

B. Volume and Levels of Service(LOS)

“Fig. 7 and 8” is the maximum hourly volume for the week, for Oke-Aro, the maximum / highest hourly volume was 1465 pcu/hr and 1201 pcu/hr which were recorded on Friday and Tuesday respectively. Also for Oke-Ijebu, the maximum hourly volume recorded on Friday was 1096 pcu/hr and 1237 pcu/hr for dir.1 and 2 respectively. In the same vein, Hospital I; the maximum volume was also recorded on Friday; 1179pcu/hr and 1304pcu/hr for dir. 1 and 2 respectively, while 1316 pcu/hr and 1312 pcu/hr recorded on Friday for dir. 1 and 2 for Hospital II. The lowest or minimum volume for the week was observed on Sundays for all the routes. The results of the maximum volume on the routes depict high level of socio-economic activities going on in these areas, and the population considered as a factor.

Table III: Maximum Hourly Volume and Corresponding Results

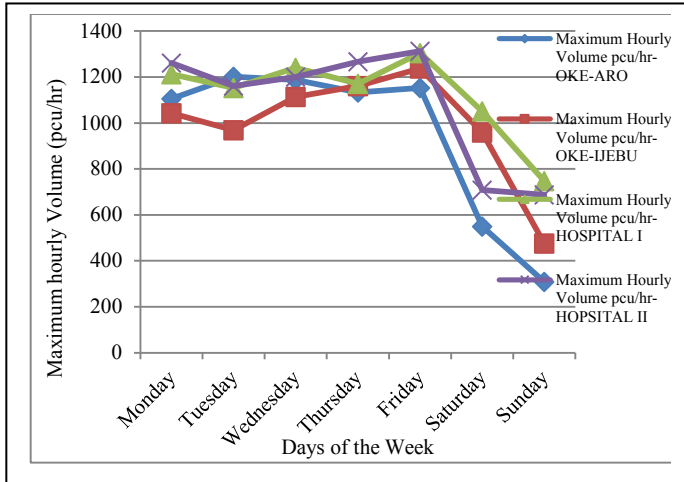


Fig. 7. Maximum Hourly Volume Variation for Weekly Traffic (dir.1)

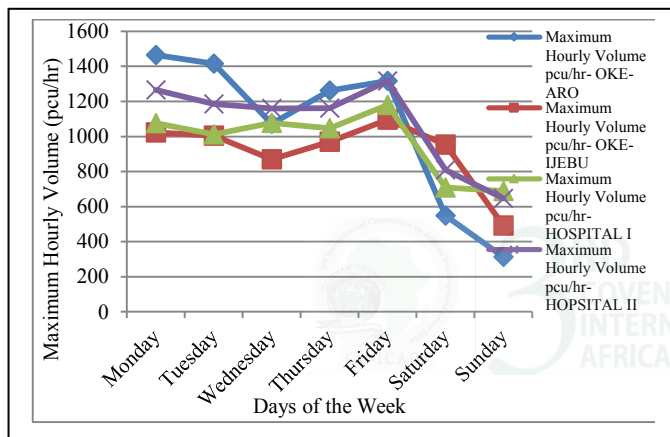


Fig. 8. Maximum Hourly Volume Variation for Weekly Traffic (dir.2)

Routes	Max.Hourly Volume-Week (pcu/hr)	Volume/ Capacity Ratio (V/C)	Level of Service (LOS)	Volume/ Capacity Ratio (V/C)	Future Level of service (10yrs)
Route 1- Oke-Aro					
Idanre Garage - Arakale Junction	1465	0.95	E	1.28	F
Arakale Junction - Idanre Garage	1201				
Route 2- Oke-Ijebu					
Oke Ijebu - Ijomu Road	1237	0.83	D	1.12	F
Ijomu - Oke Ijebu Road	1096				
Route 3- Hospital Road					
Oba Osupa To Nepa Roundabout	1179	0.89	D	1.19	F
Nepa Roundabout to Oba-Osupa	1304				
Nepa Roundabout to Hospital Roundabout	1316	0.95	E	1.26	F
Hospital Roundabout to Nepa Roundabout	1312				

Table III is the summary results for the LOS determination for the routes. Given that the road capacity is 2800 pcu/hr for two lanes roads as specified by Nigerian Highway Capacity Manual, 2010. With the aid of traffic projection equation as shown aforementioned pages of this paper, the futures Levels of Service were evaluated.

The implication and causes of level of service on each routes has been highlighted in Table IV. Moreover the future Level of Service for all the routes is “F” which signify severe congestion by 2026. However, the highest volume was recorded for Oke- Aro, which as a result of the population, income of residents, type of trips which is mostly recreational; this also influences the levels of service.

Table IV: Summary Result Showing Implication and Causes of the Levels of Service.

Routes	Level of Service (LOS)	PAG Standard	Implication of Level of Service (HCM)	Causes
Oke-Aro	E	Heavy congestion	Unstable flow, operating at or near capacity, operations at even lower operating speeds than in level "D", and any incident I create serious delays. Drivers' level of comfort is poor	Increase volume of traffic which is predominated by passenger car/taxi, increased socio-economic activities poor parking system, ribbon development, width of intersection legs is small.
Oke-Ijebu	D	Heavy congestion	Approaches unstable flow, high density, reduced speed, significant operational difficulties on the highway, delay. There are severe restrictions on a driver's ability to manoeuvre, with poor levels of comfort and convenience.	Poor parking system, abandon vehicles on road, increased volume of traffic which is predominated by passenger car/taxi.
Hospital I	D	Heavy congestion	Approaches unstable flow, high density, reduced speed, significant operational difficulties on the highway, delay. There are severe restrictions on a driver's ability to manoeuvre, with poor levels of comfort and convenience.	Geometric and/or operational constraints external to the intersection i.e faulty fixed time signal, illegal parking system, increased economic activities.
Hospital II	D	Heavy congestion	Approaches unstable flow, high density, reduced speed, significant operational difficulties on the highway, delay. There are severe restrictions on a driver's ability to manoeuvre, with poor levels of comfort and convenience.	Narrow width of circulating carriageway width of the roundabout, street trading/ribbon development

PAG: (Pima Association of Governments, 2005), HCM: (Highway capacity manual, 2010)

IV MEASURES THAT ENHANCE LEVELS OF SERVICE FOR THEIR SUSTAINABILITY

It is important to put in place measures that will facilitate favorable enhancement of Levels of Service. The results of traffic analysis and consequent level of service on each route signify traffic congestion, a menace to transportation development especially in urban cities in Africa. The following are recommended as measures to reduce the problem of congestion in urban cities using Akure as a case study;

- a. *Replacement of Existing Transport modes:* The existing predominant transport mode in Akure for commercial purpose is taxi; effort should be made by state government and private agencies to provide reliable mass transit buses or BRT in the metropolis which is a major transport facility provided in Lagos to reduce traffic congestion. Due to its vehicular capacity, it will largely decongest the road. Also the volume of motorcycles should be greatly reduced on the routes as their emission is hazardous to the environment and health of residents and road users.
- b. *Increase the capacity:* all the routes considered are single carriageway or two-lane road; expansion of the road should be done within the next 10 (ten) years in order to accommodate future traffic. The capacities of these roads are increased by conversion of the single-carriageway to a dual-carriageway.
- c. *Maintenance of Road:* frequent and regular maintenance on damage portion on the roadway will ease movement on the roadway while the

maneuverability is not influenced and sustain our infrastructural development in Africa.

- d. *Restriction of Illegal Activities:* the abolition of unauthorized terminals, illegal parking system, street trading, and abandoned vehicles is necessary to reduce congestion and maintain a favorable level of service on the road; these should be prevented and enforced by appropriate agencies.
- e. *Provision of adequate transport facilities:* provision of parking facilities and bus terminals are important facility, also traffic control system such as repair of faulty fixed time signals across each junction/intersection, expansion of intersection legs and circulating carriageway width should be put in place in order to accommodate both present and future traffic.
- f. *Diversification of Transportation System:* the over-dependence on only on one mode is a major menace that constitutes the overwhelming traffic congestion in Nigerian cities. The coordination and juxtaposition of Road, Rail, Air and Water transportation systems in Nigeria should be done in tandem with what obtains in the developed and industrialized nations of the world, where all modes of transport operate efficiently. The project could be funded from the huge revenue accruing to the nation from crude oil export, solid minerals and other sources if prudently managed. This would be "saving for the rainy day".

V CONCLUSION

The nature of traffic and corresponding levels of service on Oke-Aro, Oke-Ijebu and Hospital roads were determined through metering parameters such traffic composition and

Volume / Capacity ratio. The corresponding present Levels of Service is Poor (E), Fair (D), Fair (D) and Poor (E) for Oke-Aro, Oke-Ijebu, Hospital I and II respectively; the implication is that for all the routes; unstable flow, high density and severe restrictions on a driver's ability to maneuver, with poor comfort and convenience subsists. Increased volume of traffic, poor parking system, ribbon development /street trading were factors responsible for these Levels of Service. Assuming a traffic growth rate of 3% as recommended by [8] and a projection of ten (10) years for developing countries, the future Levels of Service for all the routes were "F" which would imply severe congestion by 2026. Therefore to sustain, develop and maintain transportation infrastructure in Nigeria, design measures such as expansion, abolition of illegal parking/ trading, provision of adequate parking facilities, repair of traffic control signals and expansion of intersection legs width and roundabout circulating carriageway width are recommended to be taken in order to reduce traffic congestion in urban cities, enhance level of service and other traffic problems. This research has shed light on the important parameters that engender various regimes of Levels of Service in the study areas, and bring out factors that enhance favorable Level of Service for their sustainability.

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REFERENCES

- [1] M.O. Popoola, S.O. Abiola and W.A. Adeniji, "Traffic Congestion on Highways in Nigeria Causes, Effects and Remedies", *World Academy of Science, Engineering and Technology International Journal of Civil, Architectural Science and Engineering*, vol. 7, pp. 259-264, 2013.
- [2] Transportation Research Board, "Highway Capacity Manual", Special Report 209, Washington D.C, pp. 3-20, 2010.
- [3] L.R. Kadiyali, "Traffic Engineering and Transport Planning", Transportation Consultant, S-487, Greater Kailash, Part 4, New Delhi, pp. 520-523, 1995.
- [4] S. Anand, Shekar, S.V.C., and M.R. Karim, "Development of Passenger car unit per hourper hour(Pcu) Values for Malaysia, *Journal of the Eastern Asia Society for Transportation Studies*, vol. 3, No.3, 1999.
- [5] A.O. Owolabi and O.O. Ojuri, "An Analysis of Traffic Volume and Parking in the Central Area of Akure", *International journal of Transport Studies*, vol 1, No. 2, pp. 40-47, 2004.
- [6] E. F. Ogunbodede, "Assessment of traffic congestions in Akure using GIS Approach, Lessons and Challenges for Urban sustenance", Department of Geography and Planning Sciences, Adekunle Ajasin University, Akungba Akoko. pp. 25-31, 1999.
- [7] G.W. Barclay, "Techniques of Population Analysis, John Wiley and Sons, Inc., New York: USA, 1958.
- [8] Transport and Road Research Laboratory, "Road Note 31" "A guide to the structural design of bitumen-surfaced roads in tropical and sub-tropical countries", third edition, her Majesty's stationery Office, 1997.
- [9] A.A. Busari, A.O. Owolabi and A.E. Modupe, "Modelling the Effect of Income and Car Ownership on Recreational Trip in Akure, Nigeria", *International Journal of Scientific Engineering and Technology*, vol. 4, No. 3, pp. 228-230, 2015.

