Analysis and Design of Smart Transportation System with 4th Industrial Revolution in Nigeria

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ABSTRACT

This paper analyzes the existing transportation systems of Nigeria and Korea and proposes a new railway and roadway design for Nigerian cities. The research findings and feasibility study revealed that the state of Nigeria's transportation system was critical as was its market segment, infrastructural deficit and financial requirement needed to implement a smart transportation system. The dilapidation of the existing infrastructure coupled with poor maintenance culture and limited public transport services has hindered the economic growth of Nigeria and its cities. A case study of Korea and Japan shows some possible solutions to Nigeria transportation challenges. Analytical and descriptive methods were used to critically assess the infrastructural challenges, movement, and convenience. The study proposed the design of a new intercity railroad and roadway across Abuja, Enugu, Lagos and Port Harcourt cities. The proposed designs have been established to be an innovative solution with advanced benefits over the current system. The implementation of the proposed designs is estimated to cost about US$(77,832,027,719) across the study areas. Thus, the discussion, conclusion, and recommendations given present a proposal to the Nigerian government on the possibility of solving the Nigerian intercity railroad and roadway transportation challenges across Abuja, Enugu, Lagos and Port Harcourt cities through smart designs.

Key words*: Transportation, Smart Design in 4th Industrial Revolution, Intercity, Roadway, Railroad.*

1. INTRODUCTION

The poor transportation design and planning has resulted in the failure of most cities to meet the transportation need of the residents. Also, the massive migration of people from rural areas and satellite towns to cities has increased pressure on the city transportation infrastructure and discomfort to the public due to the growing economic activities in the cities.

The rapid growth of Nigerian cities and population is negatively affecting the transportation needs of the cities, also the city authorities are not prepared for the growing influx into the cities. Over the years, the railroads and roadways infrastructures have been neglected by the city authorities. The infrastructures were either abandoned or poorly executed thereby leaving them in a bad state which kept the transportation of goods and passengers in terrible condition [1]. The current state of Nigerian transportation system is at the point of comatose, complexity and immobility as population and city growth have outnumbered the transportation infrastructure and services available to serve the city and its people. Unlike in the 1970s when transportation system was more effective in relative to a number of cities and population of Nigeria as at then, In 70s the movement of people and goods was much faster and easier than the current state [2]. The aforementioned challenges have contributed to city transportation problems including traffic congestion, air pollution, stress, health challenges and insufficient mass transit vehicles needed to convey passengers and goods. The demand for public transport system has risen unceasingly as the

urbanization spreads. Some studies conducted in the past on the roles and adverse effects of transportation in cities by Vuchic, 2005; Sperling, 1995 and others shows that transport is the main mover in charge for both economic success and failure, especially where economic means and conditions of human endeavor is inadequate [3]. In addition, a transportation system that is highly proficient should be seen as the factor that bonds the whole economy and expedites development.

The transport sector is essential to reducing poverty and building prosperity to give access to jobs, education, and healthcare; it connects goods and services to markets and it is a key driver of economic growth. Also, the advancement, application and use of information Technology in transportation sector has improve the operational activities of city transports for both inter-city and intra-city. The leading modes of transportation in Nigeria are roadways and railroads. Among modes of transportation, the roadway is the major means of transporting goods and passengers within Nigeria [4]. The South Korean and Japanese transportation breakthrough have suggested solutions to Nigerian challenges. This paper reviews and analyzes the current transportation system in Nigeria and provides a smart transportation design based on case study of South Korea and Japan.

2. LITERATURE REVIEW

Transportation has been identified as a key to national development. The World Bank in 2016 viewed transportation as a catalyst for economic growth of nations [5]. It impacts other sectors of the economy and strengthens productivity of any nation. This study reviews the efforts made by the Nigerian government in the transportation sector; the shortfalls and milestones achieved, it also reviews the previous work done by other scholars on Nigeria transportation sector especially on the railroad and roadway.

2.1 Railroads Development in Nigeria
As There was a decline in Nigeria railroad infrastructural development after the 1980s; the Nigerian government has neglected the railroad sector leading to infrastructural deficit on rail transportation [6], in addition, factors like ineffective management and corruption in the Nigerian Railway Corporation as well as the overbearing influence from central government adds to the railroad development problems [7]. The railroad plays a major role in logistic activities and has an edge over other modes of transportation due to its visible contribution to nation's economic advancement and mass movement of people and goods on land. Nigeria is yet to leverage on the benefits from the railroad to advance her economic development. There have been no tangible infrastructural development and investment in this sector which has greatly affected the growth of Nigerian economy. It was observed that the development was quite different during the colonial era [8] and at the early independent stage when the railroad played a major role in Nigerian economy [9]. In the Past, the nation uses rail for economic growth through transportation of major goods to the port for foreign export. The western Nigeria uses rail to transport cocoa, the Eastern side conveys coal while the Northern Nigeria conveyed groundnuts by rail.

Nigeria inherited a vibrant, buoyant, prosperous and effective railway system from colonial masters from 1898 – 1960. The railway system run two parallel to each other from South-West to North-East another from South-East to North-East, all single gauge [10]. Odeleye detailed that the Nigerian railway lines are made up of 3,505 kilometers of slender gauge (1.067m), single track running parallel through north-west to south-west and from south-east to north-east of the nation. 1788km of this system is on 1,600 sharp bends in the vicinity of 4 and 10 degrees, and this has diminished the most extreme allowable speed to 65km/h [10] and 45km/h [11].

Surprisingly, after colonial authority left, there were no significant track augmentations made by the administration in the previous five decades. Essentially, the current system is the frontier relics Nigeria acquired from the colonial era. The complete neglect of the railway system by progressive governments had plunged the railway system in Nigeria into a condition of torpid. Following twelve years of freedom, the Nigerian Railway Corporation started recording decline in revenue, a pattern that has not just proceeded however has expanded in hugeness [10].

According to Akarawak, more revelations were shown on the comparative analysis on the percentage of cargo carriage by rail and road transport system. Table 1 below compared the two cargo carriage from 1995 to 2000 [12].

Table 1. Comparing tonnage carried by rail and road [13]

Year		Import	Tonnage Carried by rail	%	Tonnage carried by road	%
1995		4,690,585	4,832	0.10	4,685,755	99.89
1996		4,606,575	2,752	0.06	4,603,823	99.94
1997		4,326,542	2,752	0.66	4,323,790	99.94
1998		6,541,330	15,320	0.23	6,526,010	99.77
1999		7,271,662	18,381	0.24	7,703,241	99.76
2000		9,046,522	20,642	0.23	9,025,880	99.77

Table 1 above shows the average tonnage carriage capacity of 99.85 percentage by road while rail only contributes to 0.25 percentage on average. This shows a huge margin between the two main transport systems and gap that need to be filled. In a similar circumstance as recorded in 2002, Nigerian Port authority handles 35million tonnes of cargo as compared with Nigerian Railway Corporation 1.5million tonnes.

Investment in railroad development has experienced poor attention from investors; this sector is yet to be utilized to enhance national economic growth [9]. There was an effort in the past to get private investors involve through the Bureau of Public Enterprise BPE privatization moves which failed due to unknown reason [14]. Another concern on the side of investor was the widely publicized corruption of the administration in charge then as well as the previous NRC profile on debts owned [14]. More effort was sought in 1995 between the Nigerian government and the Chinese government to resuscitate the railway infrastructural decay and its operation in Nigeria, a bilateral agreement was signed for the implementation modalities, but this failed to see the light of the

day as then head of government died 2years after the agreement. The subsequent government failed to pursue the agreement of 1995 [14]. This has created a gap in the railway development in Nigeria.

2.2 Roadways Development Status in Nigeria

It is essential to take into cognizance the importance of roadways in the economic development of any nation; it has been identified as a primary mode of transportation and currently dominates the Nigerian transportation sector [15]. Nigeria has 193,200km of roads of which 28,980km was paved and 164,220km was unpaved and its ranked 29th amongst world roadways in terms of length [16]. Comparably, the National Planning Commission in 2015 asserted that Nigeria total roadway is 200,000km of which 18% of the road is made up of federal highways and the 15% of it comes from state roads whereas 67% is for the local government roads [17]. The infrastructure on the ground shows that most of the paved roads are Federal and State roads while the local government roads are the most unpaved roads [17]. The current strength of Nigerian transportation system heavily depends on road transport as 90% of the total passengers and good conveyance are done via road, 70% of the road movement happens on federal road and 40% of this federal road is not in good shape, the 30% of it is in manageable condition whereas the 27% of the federal road is in good condition [17]. The poor roads need quick rehabilitation, the poorly managed roads require periodic maintenance whereas the good and unpaved roads require routine maintenance and standard paving respectively.

In addition, state roads face similar or even worst scenarios, the state roads have 78% inadequate roads whereas 87% of local government roads are in terrible condition [17]. Unlike in 1955 to 1977 when railroad dominates the transportation sector in Nigeria, the case now is reversed, the road transportation contributes 90% of the movement of people and goods, this is characterized by high transport fare, slower speed pace, potholes, unreliable service and poor maintenance [18]. After a huge decline in rail infrastructure in the late 1980s, there was upward increase in vehicle purchase and registration up to 439% and the motorcycle registration reached 930% [18]. Statistics have shown that out of 200,000km of roads in Nigeria only 65,000 are bituminous [18]. The road transport in Nigeria has become the primary mode of transportation and had relegated the rail transportation to the back seat [18]. Road transportation has been identified as a major enabler for new economic activities as it opens up remote areas and draws social-economic development to the area, offers easy access to market trading purposes, it enhances agricultural productivity and map out a path for urban development [18]. It's obvious that other mode of transportation will unlikely thrive without the support of road transportation, for instance, air, rail, and water all required some degree of road transportation to convey goods and people to the terminal or stations [19]. Roadways serve as the primary mode of transportation that conveys passengers and goods directly to houses and offices. It acts as a catalyst for rural development and it has played a central role in the development of Nigeria towns [20]. The current roads need to be widened to accommodate more vehicles, new constructions should be embarked upon, the single lane should

be expanded to 6 or 8 lanes to reduce traffic and improve transportation infrastructure as well as traveler experience [20]. These will help improve Nigeria wealth. In addition, highways construction contributes to the economy of rural communities by increasing retails and manufacturing industries and offering employment in aforementioned sectors. It also connects the rural areas to cities [21].

More research work has shown that most road construction in the cities was done at the early formation of the city, especially at the city center and national expressways without taking into cognizance about the growth of city population and number of vehicles acquisition and usage on the road. The roads in such cities are characterized by having a major road network, emanating from the center of the city and spreads to its environs without having any proper links and connections to its surroundings [22]. The condition of major roads in Nigerian cities could be reconstructed to correct these flaws, but that will come at a heavy cost ranging from human rights infringement, destruction of several existing houses and structures in order to correct the wrongs of the past caused by poor planning. Therefore, restructuring or widening of the roads may not resolve the traffic problems without recourse to aforementioned problems [23]. Apart from major cities like Abuja and Lagos other cities do not have proper bus terminals; it has been replaced with motor parks [24]. In 2009, Federal Road Safety Commission went on a fact-finding in the process 2,476 motor parks across Nigeria were discovered. The findings showed that 60 percent of these motor parks are in urban towns and were part of the cause of traffic congestion even when it was involuntary; also they are largely messy, parks are overfull and most of the cities do not have any existence of pedestrian walk paths except Abuja and Lagos which is structurally well planned, other cities have few pedestrian bridges and crosswalk provided at city hub [23], [24].

2.3 ICT in Transportation

Information and Communication Technology is playing a vital role in the transportation sector; it has helped to minimize the cost of labor and infrastructure. The success made so far on the present supply chain is attributed to the use of ICT tools. The transportation industry, especially in the area of movement of people and goods from one location to another, there has been a great advancement in the recreation of solutions and technical infrastructure that are aiding numerous commercial activities. The industry has seen a tremendous reduction in cost and advanced consumer service and satisfaction due to the introduction of ICT that creates an enabling environment for competition. The competitive environment is rampant in road transportation sector where passengers are seeking for greater quality of service while expecting to pay less. This creates a healthy competition among transportation companies who strive to use technology and innovation to have an edge over their peers as well as dominate the marketing space. Several scholars have identified ICT as a major mover of road cargo transport business [25]. Satisfying passengers' needs and considering their changing tendencies was a major gain of having flexible ICT tools that could be used to meet this need by responding and changing the system to meet their needs. In

addition, ICT helps to maximize profit by reducing the cost of operation and proffers safety trips. Tools like sensors, actuators, and other technologies are applied to tollgates, traffic lights, speed limit checker and others to control and manage the movement of cars and trains.

3. RESEARCH METHODOLOGY

The study uses the analytical and descriptive methodology to analyze the existing transportation infrastructure in Nigeria, the movement of people and cargos. The method was also used to conduct a critical feasibility study on market, technical and financial analysis of implementing a smart transportation system across Abuja, Enugu, Lagos and Port Harcourt cities.

In data collection, the primary data used in this study was an interview with Nigeria Railway Corporation NRC and Federal Ministry of Transportation officials whereas the secondary data was collected from National Bureau of Statistics NBS of Nigeria, Nigeria Railway Corporation NRC, National Planning Commission NPC of Nigeria, Federal Ministry of Works FMW, Knoema (World Data Atlas), Central Intelligence Agency CIA amongst others to interpret transportation challenges in the study areas.

Additional secondary data was collected from relevant institutions, previous survey, articles, statistics, and publications. In presentation and data analysis, cross tabulation, percentages, regression model, and analysis of difference was used.

4. CASE STUDY

4.1 Korea and Japan Experience

4.1.1 Korean Experience:
In the 1960s, Seoul the capital city of Korea government experienced rapid urbanization growth; there was a massive movement of people from suburban areas into the city [26]. The influx of people into Seoul metropolitan area coupled with the city's status as the capital. After the 1990s, the growth continued due to the increase in wages and personal cars as well as the Seoul Olympic of 1988 lead to a gigantic influx of automobile into Seoul city. Then the 50% of the South Korean automobiles reside in Seoul Metropolitan Area, and statistics had shown that about 1million cars in 1990 increased to above 2million in 1995 [27]. Furthermore, in 2009, the total number of the automobile in Seoul raised to 3million making it 17.1% of the total car in South Korea. These huge numbers of human migration and automobile created dense traffic rise in Korea. There was a limitation on road capacity to cater to this huge population mobility. The congestion in Seoul resulted in the loss of over KRW 7 trillion, due to socio-economic effects that are higher than what was experienced in 1991 [27].

The continuous increase in a number of the automobile in Seoul resulted in heavy traffic congestion, air pollution, and health hazards, thus a need to provide a solution to improve the city's competitiveness. The first step taken was the conversion of privately owned buses to semi-public operation system needed to serve the public interest. The rudimentary methodology adopted for the semi-public process arrangement was a combined management of revenue from bus charges and bidding for bus routes. They had a collective pool of income from buses and distributing them contingent on the working performance. The fares were maintained by an organization and supported by the government when it is not enough. Relative revenue stability was achieved in the bus operation as the organization and backup from government helped bus companies to eliminate loss. The adopted bidding system helped the union to cover the entire bus route and enhance the effectiveness of urban transportation. The private firms selected through bidding for suburban routes were advised to manage and minimize the cost of fleet and labors while the Seoul routes were fully managed and maintained by Seoul Metropolitan Government who often changes the route based on the municipal request. There were recorded discrepancies that existed between the bus operators and driver unions, but that was resolved by the Seoul Metropolitan Government through the implementation of citizen-friendly bus route system. The Seoul government intervention helped to get public transports to places where bus operators deem unprofitable to them. The Seoul city and nearby suburban areas where able to overcome traffic congestion in some route by enforcing the bus operators routes through bidding and public demands [28]. The Nigeria private bus operators are not confined to a specific route and there are still crashes between bus operators and driver unions. This approach could be adopted by Nigerian Union of Road Transport workers NURTW and city metropolitan authorities.

The Korean government embarked on High-Speed Railways projects as far back as 1984, the conception of the project was heavily backed by the government authority and was headed by the prime minister at that time. The Government of Korea started the feasibility for the construction of KTX in 1984 [29]. This feasibility continues till 1989 when a special committee was set up by the government which was headed by the Prime Minister to usher in the laid down policy and regulations for the development and railways sector. From 1989 to 1991, further study was initiated to ensure successful delivery of the project [29]. In March 1994, a year after, the Korean government established the Korean High-Speed Rail Construction authority, in the June of the same year, the government kick-start a test-track segment of the project, by laying the foundation for a 57km railroad from Chuan and Daejeon. The project continued and in June 1993, the project fund was not sufficient as initial budget of 5.8 Trillion Won was mapped out for the project, also there was modification of High-Speed Railway as a result of high raise in the project cost, an additional fund of 4.94 Trillion Won was provided to get the project going, making the total cost of the projected rise to 10.74 Trillion Won. This saw the project develop going and in 1998 there was a second amendment of the KTX master plan which forced the original commission date of 1998 to be changed to 2002, the target was not meet on 2002 and then was extended to 2004. This project was successfully completed in 2004 and commissioned [29].

The Korean government understood the importance of transportation system to link all region of the country as a huge booster to her economic development, the authority reaffirm

the fact that upsurge in the entire mileage of nation's urban railroads was considered a major contributor to her per capita GDP. This confirms the link between the economic growth of the country and construction of city railroads infrastructure. In Korean cities, traffic occurs during the morning hours and at evening times which overfilled in certain spots. The traffic is also experienced during a special holiday in high ways, but in the central city, traffic congestion is seen at the peak hours when people are returning to satellite towns [26]. The authority saw the need for efficient and effective public transportation system that could deal with traffic demand of the cities as critical, a typical example is shown in Fig. 1 below.

Fig. 1: Bus-Centric Urban transportation in Seoul in the 1960s [26]

In terms of transportation efficiency and punctuality, city railroads are seen as most reliable mass transit that excels more than other known mass transits due to its properties of multi-train vehicle drive along the dedicated tracks. It reduces gas emission and pollution, energy efficiency and guarantees safety when compared with cars. This made the Korean Government consider this approach as the most effective for her metropolitan cities in reducing or eliminating both intra-city and intercity traffic congestion [26].

4.1.2 Japan Experience:
In Japan, the political influence in all sectors of the economy was worrisome including the railroad development, this problem which was similar to Nigerian current problem lingered in Japan till 1987, and the motivating factor then in Japan was the high social economic benefits that investors obtain from transportation facilities. The projects were abused when investment comes from the local or central government, transparency was loss and politics reigns in business while the poor masses bear the problem. Railroad transport infrastructural development in developing countries is highly influenced by government especially when the project is fully financed by the government. Politicians play politics when its state-owned railroad infrastructural development, nepotism and regionalism becomes the riding factor for the choice of project location even when it's not economically viable to establish such project in a politically motivated and driven decision. Such decision is not obtainable in private sector where proper economic benefit survey is carried out before investing a huge amount of money on infrastructural development, but the government-owned agency the experience is totally opposite. During the reign of the old Japan National Railways JNR,

every region must demand its own railroad development even where it is not economically feasible [30].

The Japan experience before 1987 is the current experience in Nigeria now with the Nigerian Railways Corporation NRC, they are the body mandated to direct and control the railway infrastructure, but as government-owned institution, top government officials decide what happens within the agency, these high political class individuals determine how investment should be made and daily operation of the railroad activities. Leaving the instituted management of the agency paralyzed and incapable to make an investment decision on where railroad infrastructural development should be situated or fare to be charged. Critical decisions could not be taken by the management of NRC without interference from Federal Ministry of Transport or the presidency. The Nigeria current problem on railroads is a typical scenario of Japan before privatization intervention that saw the end of JNR, and then JNR could not make a decision on its own to change the transport fares which provides the revenue without recourse to the power brokers in the seat of power [12].

In addition, JNR was handicapped as they solely depend on the ministry of finance for budget approval and fund, the government which was controlled by the Liberal Democratic Party LDP. This has been the situation in Nigeria for the past 30years of railroads rehabilitations, reforms and transformations. The unneeded bond between the agency of government and the political leaders create enabling an environment for corruption to thrive between railroad business and politicians. The Japan success story in breaking the bond between railroad business and politician influence had seen the country advance her railroads infrastructural development to what it is today, Nigeria should learn from this approach and adapt it to transform her railroad sector.

To make tangible progress in Nigerian railroad there must be a solution to eliminate corruption that exists between business and politics. Japan overcome this problem in 1987 by modifying the country's railroad laws to usher in the privatization of JNR. Nigeria should emulate Japan railroads law reforms by amending the 1955 act of legislatures that mandated the federal government to solely handle railroad development in Nigeria. This could be the only way the country will experience advance growth in railroad infrastructural development, smooth operation, and increased train speed. The developed countries in the past had similar challenges, but reform in railroads with supporting legal framework allowed private investment into the railroad, today they are reaping the gains of these reforms. The Japanese experience has shown how progress could be made in railroads and how to minimize the influence of external forces in railroad institutions as well as diminish the political controls of leading political parties and make the railroad's institutions autonomous and fully independent in Nigeria [12].

4.1.3 Result of Case Study:
The result of the case study shows that Korea experienced several transportation problems in the past like having numerous cars on the roads which causes traffic congestion and socio-economic effects, increased traveling time, and creates environmental impact such as air pollution, accidents, and

others. There were limited public mass transit buses and a limited number of train lines. These problems were resolved by conversion of privately owned buses into semi-public operation system; drivers were allowed to bid routes and were supported by the government like a subsidy. In other to create another channel of transport, the government invested in rail transportation to connect the major city. This helped to reduce the aforementioned challenges faced by the Korean cities habitats.

In another case in Japan, there was political influence and monopoly on transport agency like the Japan national railways JNR. In addition, there was stringent railroad laws and policy that do not support privatization. The roads were characterized by narrow paths and traffic congestion was at its peak. The government authority resolves these problems by first enforcing privatization of the country's railroads and amended the laws and policy on railroads to allow privatization of sector. The narrow roads were expanded to accommodate more vehicles; when Downs-Thomson Paradox proof as confirmed by another scholar Wood shows that travel times in Japan increase after the implementation of the aforementioned solutions.

4.2 The Current Nigeria Transportation Infrastructural Analysis

4.2.1 Road Analysis:

Table 2. Nigeria road network statistics (FMW, 2013), ** [16]

National Land Area : 910,768 sq. km					
The Length of a road per km^2 of National Land (Road Density) is 0.22 km/km^2					
Road Type	Extension (km)	Pavement Ratio (%)	Composition (%)	Traffic Volume (%)	Poor Condition (%)
Federal Express way	33,000	81	16	70	40%
State Highway	50,000	22	25	20	78%
Local Roads	117,000	13	59	10	87%
Total	200,000	33	100	100	

As shown in Table 2 above, Nigeria national land area is 910,768 km^2 with a total 200,000 km length of roads. The road density stood at 0.22/km^2.
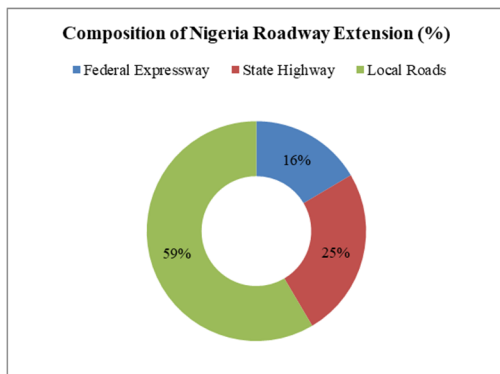

Fig. 2: The composition of Nigeria Federal, State and local roads by percentage

The Fig. 2 above shows that the federal expressway contributes 33,000 km length of road which accounts for 16% of total length of roads in Nigeria whereas the state Highways contributes 50,000 km length of roads that is equivalent to 25% of the total roads in Nigeria and the local roads has the highest length of road in Nigeria with a total of 117,000 km which is equivalent to 59% of total roads in Nigeria. The percentage of the total paved road in Nigeria is only 33% of Nigeria road extension (200,000 km) which is 65,000km of roads.
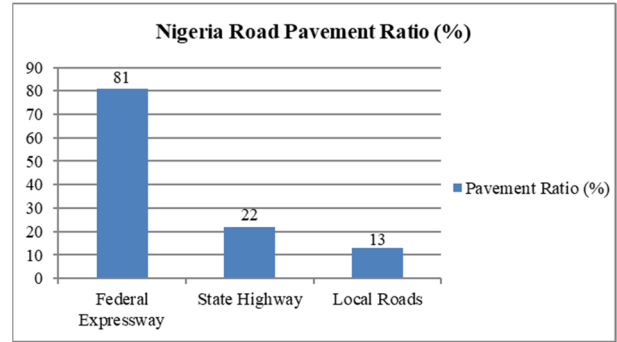

Fig. 3: Nigeria road pavement ratio

The Fig. 3 above shows that the most paved road in Nigeria is the federal expressway, 81% of the federal expressways are paved while the state highway has 22% of paved roads and the local road has only 13% paved roads. This shows that most of the local roads in Nigeria are not paved.
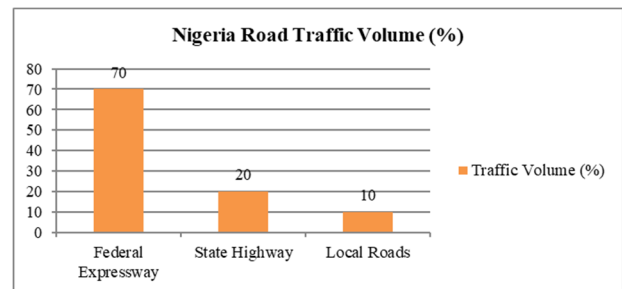

Fig. 4: The percentage of road traffic in Nigeria

In terms of traffic volume, the Fig. 4 above shows that the federal expressway is the most used roads in Nigeria for the conveyance of passengers and goods from one destination to another; it contributes 70% of total traffic volume in Nigeria. The state highway traffic volume stood at 20% while local roads traffic volume contributes only 10% of Nigeria roadway. Most of the Nigerian roads are in terrible condition, 40% of federal expressways are in the poor state whereas the state highways have 78% poor roads and the worst amongst all is the local road which has 87% of its road in the unusable state.

Table 3. South Korea road network statistics [31]

National Land area : 96,920 sq. km			
The Length of a road per km^2 of National Land (Road Density) is 1.1km/ km^2			
Road Type	Extension (km)	Pavement Ratio (%)	Composition (%)	Traffic Volume (mn . km)
National Expressway	3,447	100	3.3	39%(143)

National Highway	13,905	97.4	13.4	39%(142)
Provincial Roads	86,884	74.5	83.3	22%(82)
Total	104,236	78.5	100	368

The Korean case is different as shown in Table 3 above, although her national land area is 10times smaller than Nigeria; the road density is much higher than that of Nigeria. The land area, as shown above, is 96,920 km^2 while the road density is 1.1 km^2. The total road extension in Korea is 104,236 km and it is consist of 3,447 national expressway, 13,905 national highway and 86,884 provincial roads which are equivalent to 3.3%, 13.4%, and 83.3% of the road extension respectively. The pavement ratio shows that national expressway has all his roads paved which stood at 100% while national highway has 97.4% of its road paved and the least paved road in Korea is the provincial roads, it has 74.5% of its road paved. In total 78.5% of Korean roads are paved. The national expressway and national highway are both leading in traffic volume with 39% respectively while provincial roads contribute 22% of road traffic. Korean roads have a balanced traffic volume as both national expressway and national highway have 39% traffic volume while the provincial roads have 22%, but that is different in Nigeria. In Nigerian case the federal expressway dominates the traffic volume in the country; it controls about 70% of road transportation traffic in Nigeria while the state and local roads control 20% and 10% road traffic volumes in Nigeria respectively.

4.2.2 Road Analysis:

Table 4. The overview of Nigeria railroad [32], **British Broadcasting Corporation [11], ***Nigeria Rail Standard Gauge Speed [33]

	Track Line	Extension (km)	Ratio (%)	Gauge Track	Gauge Type	No of Stations	Speed (km/h)**
1	Single	3,282	87	1.067-mm	Narrow Gauge		45
2		453	12	1.435-mm	Standard Gauge		90 ***
3	Double Track	30	1	1.067-mm	Narrow Gauge	26	45
	Total	3,765	100				

Table 4 above shows the statistics of Nigeria railroad as at 2016. The total railroad extension in Nigeria is 3,765km which consist of 3,735km single track line and 30km of double track line. The average speed kilometer per hour is 45km/h.

Table 5. Overview of South Korea Railroad [34]

	Track Line	Extension (km)	Ratio (%)	Gauge Track	Gauge Type	No of Stations
1	Single	1,594.1	41	1.435-mm	Standard Gauge	
2	Double Track	2,279.4	59	1.435-mm	Standard Gauge	673
	Total	3,873.5	100			

In Table 5 above, the statistics show that Korea has 3,873.5km of railroad extension that consists of 1,594.1 km of single track line which represents 41% of the total railroad

while 2,279.4 km are double track representing 59% of the total railroad in Korea. Both the single and double track lines are standard gauge track of 1.435-mm. The total number of the train station in South Korea is 673 stations.

In comparison, railroad network statistics of Nigeria and South Korea as shown in table 4 and 5, shows that Nigeria has 99% of its tracks on single track line while South Korean has 41% single track line. In addition, Nigeria has only 30km of double track line within Lagos city whereas South Korea has 2,279.4 extensions of the railroad on double track across the country. Nigeria has only 26 train stations while South Korea has 673 train stations. The data shows that South Korea railroad extension is longer than Nigeria by 108.5km even with a smaller population of 50million people when compared with Nigeria 186million population.

Table 6. Comparing Nigeria to South Korea Railroad Density

	Country	National Land Area (km^2)	Total Extension (km)	Density (km/km^2)
1	Nigeria	910,768	3,765	0.0041
2	S. Korea	96,920	3,873.5	0.0399

Table 6 above shows the railroad density of Nigeria and South Korea. Nigeria total railroad length is 3,765 km and its national land area is 910,768 km^2. The railroad density of Nigeria is 0.0041/km^2 while that of Korea is 0.0399/km^2. This shows that the railroad infrastructural deficit in Nigeria is the alarming stage. Although Nigeria was ranked 47th in the world railroad rating based on railroad extension. The nation is far from meeting its railroad infrastructural need as shown in the railroad density value in Table 6 above.

5. THE PROPOSED NIGERIA TRANSPORTATION SYSTEM

5.1 Infrastructural Re-design for Railroads and Federal Expressway across the Study Areas

The proposed solution recommended the public-private partnership between private investors and government on infrastructural development and management through the operation of the system for several years to recoup the investment made by investors. This model has worked for many countries including South Korea and Japan as shown in the case study.

The author has proposed a new design for Nigeria railroad and roadways based on the study area covered in this research as shown below.
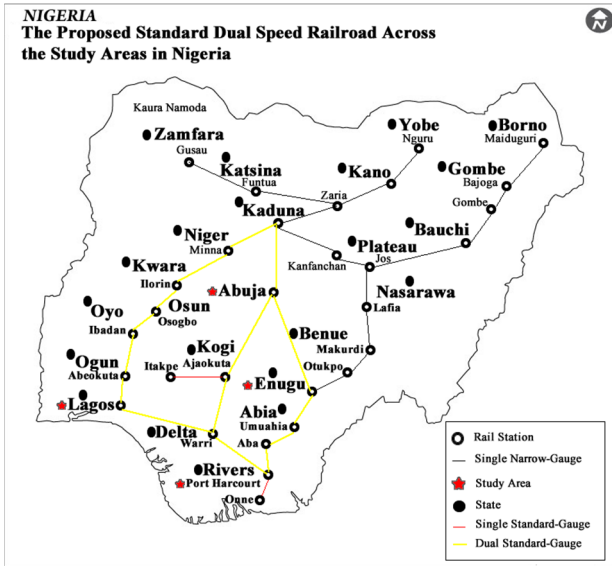
Fig. 5. The proposed new railroad design across the study area

Fig. 6. The proposed federal expressway design across the study area

The Fig. 5 above shows the proposed railroad extension and its rail stations. The red star signifies the study area while the yellow lines depict the proposed dual standard gauge track. The black circle with a spot at the center represents the rail stations, the black spot represent the states, and the red line represents single standard-gauge while the black line represents the single narrow-gauge not covered in this study. The dual new track to be constructed is made up of 1,460km rail extension while the existing single track gauge that needs dualization and rehabilitation is 1,333km. Total rail track to be constructed is 2,793km. Along the paths of the rail track, there will be 14 stations within the scope of this study to be constructed and additional 2 stations between Kaduna to Kano making it a total of 16 stations. The choice of including 2 more stations out of the scope is because of passengers' traffic volume between Kaduna to Kano.

The rail stations will be installed with high-speed wireless internet connections. The dualization of these rail lines both existing and the new ones will greatly bring Nigerian railroad back to its golden position as it was in the 1960s. The proposed railroad will have 20 modern locomotives trains that consist of 5 cargo trains and 15 passengers' trains all furnished with a high-speed wireless internet connection. The trains will be moving at high speed of 201km/h unlike the current average speed of 45km/h. The estimated cost implication for implementing the proposed rail tracks, stations and trains are US$(52.3billion). The targeted population is over 72million people living in the covered area.

The proposed railroad will increase the number of passengers, the volume of freights and decongest traffic on roadways. The new design is expected to advance the number and volume of aforementioned passengers and freights respectively by 200% unlike what is obtainable now.

On the proposed federal expressway as shown in Fig. 6 above shows that Lagos – Abeokuta – Ore – Benin City – Lokoja – Enugu expressway will be dualized and expanded like the existing Lokoja – Abuja expressway. The entire existing dual expressway will be rehabilitated and place on routine and periodic maintenance to avert having the roadways deteriorating into the unusable situation. In Fig. 6 above, the yellow line depicts the proposed dual expressway while the red line shows the existing dual expressway that is in poor condition which needs rehabilitation. The red star shows the study area covered in this study while the black circle with a white spot at the middle represents the bus terminals. The black spot represents states while the black lines represent the roadway that is not covered in this study.

The study has identified that 689km of the dual carriage in the study area are in poor condition; these federal expressway extensions will be rehabilitated and placed on routine and periodic maintenance. In addition, 839km new federal expressway will be constructed beside the existing single lanes to make it dual lanes. The existing single lane will be rehabilitated and placed on routine and periodic maintenance as well.

The proposed solution is expected to reduce traveling times by 30% of the original time. Specifically, the research showed that from Port Harcourt – Enugu takes 4hours 2minutes, Enugu – Abuja takes 6hours 19minutes, Abuja – Lagos takes 10hours 29minutes and Lagos – Enugu takes 7hours 41minutes. These federal roads are characterized by potholes and damaged asphalt thereby causing slow speed movement of cars and traffic congestion on the road. In Addition, having single lane increases accident on federal expressways as departing and returning vehicles compete for space and dodge potholes leading to car collisions on the road. The new design includes 12 toll gates to be used for road tax collection as a means of recouping the investment on the federal expressway by investors. The road users will pay a fixed amount of money depending on the type of vehicle.

The new system will have dual carriage for the entire federal expressway covered in the study. The damaged ones will be rehabilitated and place on constant maintenance to avert future occurrences. The number of hours spent on roads will be reduced; the implementation of dual carriage will significantly reduce road accidents and traffic congestion. Improved road transportation will contribute to the advancement of other sectors of economy and GDP of the Nigerian economy. Freights services will be smoother and efficient with the new design. The author has also implemented a web portal system to cover these routes proposed in this study. This will enable passengers and freight service to book ticket and pay for them online as described in details below.

6. FEASIBILITY STUDY

6.1 Feasibility Assessment

In market analysis, the author observed that Nigeria has the leading population and biggest economy in the region. Also, Nigeria is considered the most profitable destination for investment in Africa. The country's GDP in 2016 stood at $406 Billion and GDP Per Capita was $2,457.80 and was ranked 24th and 106th respectively in the world. In addition, 55.3 million passengers were transported through four modes (Road, Air, Rail, and Water) of transportation in 2016, in the same year, 26.2 million ton-km of freights was transported. The road and air transport lead as 1st and 2nd respectively in the number of transported passengers and goods in 2016.

The cities of Abuja, Lagos, Enugu and Port Harcourt were chosen due to their market size and economic viability. The cities have a total population of 27million habitats. The roadway and railroad extensions connecting these four cities have other 10 Nigerian states and other cities linked to them along the routes, these linked states have a total population of 46 million. The transport fare is reasonably affordable. These cities have a high number of internet users and ICT literacy rate is higher when compared with other cities.

Table 7. Number of internet users in Nigeria [35]

Number of Internet Users in Nigeria	Year
91,565,010	**2017**

In line with the proposed online ticketing system in the study, the integrated smart transportation system requires a level of ICT literacy by passengers to operate. The market segment is considered to possess higher internet users as shown in table 7 above.

The technical analysis shows that the infrastructural gap between Nigeria and South Korea is too wide. The Korean Road density is 1.11 and railroad density is 0.0399. This could also be seen in the percentage of paved federal expressway where 100% of Korean national expressway is paved while only 81% of Nigeria federal expressway is paved. The paved Nigerian federal expressway has 40% of it in poor condition, 30% of it is in fair condition, 3% is in bad condition and only 27% is in good condition. Most of the roads were poorly constructed with cheap materials; they are characterized by potholes and erosions.

The railroad is even worse than the roadways as most of the rail lines are running on the single narrow gauge with obsolete locomotive trains on the average speed of 45km/h. Only 453km of railroad extension was built on the standard gauge that represents 12% of the total railroad length and runs on 1.435-mm gauge track while the rest of the railroads run on the narrow gauge of 1.067-mm. The only existing double track line in Nigeria is the 30km length of railroad within Lagos city. Nigeria has only 26 train stations across the country. The total number of railroad extension in Nigeria is 3,765km which falls below expectation as a number of the national land area is above 910,000km^2.

The financial implication of rebuilding the Nigeria railroad and roadway infrastructures is tremendous considering the current infrastructural deficit, Nigeria land mass and population. In the technical analysis, the author observed that Nigeria need 10times of the existing 3,765km of railroad extension which is 37,650km to be able to meet the railroad need of the Nigeria railroad passengers and to attained South Korean railroad extension standard. Also, the existing railroad in Nigeria requires a huge amount of money to be reconstructed into double track standard gauge high-speed rail lines and to build more train stations. In the case of the roadway, 33,000km of the federal expressway need fund to rehabilitated 73% of the roads damaged by potholes and other factors since only 27% of the roads are in good condition. Dualizing single federal expressway requires lots of money as well. The author has decided to tackle these problems based on the study areas which cover Lagos, Abuja, Enugu and Port Harcourt as well as the linked cities. The scope is based on the market size of the study areas, its connection to other cities and economic viability of the chosen cities. In addition, the author also considers the financial limitation of the Government and also considers the Public Private Partnership PPP to embark on the overall implementation of the findings at once.

The estimated amount required to upgrade Nigerian railroads and roadways in the study area is Seventy Seven Billion, Eight Hundred and Thirty-Two Million, Twenty Seven Thousand, Seven Hundred and Nineteen US dollars US$(77,832,027,719).

7. CONCLUSION AND RECOMMENDATION

The study has critically analyzed the Nigerian and South Korean transportation infrastructure which shows the poor state of Nigerian transportation sector. In the infrastructural analysis, Nigeria needs 10times of South Korean investment on railroad and roadway transportation to achieve a better transportation design to serve her growing population.

A new railroad and roadway were proposed in this study to connect the four major cities of Abuja, Enugu, Lagos, and Port Harcourt. The railroads were redesigned to support dual track, standard gauge, more rail stations, trains and wireless internet connections. The 1,460km new railroad was proposed to be constructed while 1,333km of existing ones will be dualized and rehabilitated. For the roadways, the single

carriage was redesigned into the dual carriage; the bad roadways were marked for rehabilitation. The entire federal expressway was redesign to run on the dual carriage and to be maintained periodically and routinely.

The feasibility analysis conducted shows that 73million population across the study areas need transportation infrastructure and services, it also shows that 95million Nigerians are active internet users. On the technical analysis, the current transportation system in Nigeria is obsolete and requires an upgrade to meet the modern standard used in South Korea, including, trains, buses, rail stations, rail track, road paths, and terminals. The Financial analysis shows that Nigeria needs US$(77,832,027,719) to implement the newly proposed railroad and roadway design.

The study has recommended the followings for reviving the railroad and roadway in Nigeria cities of Abuja, Enugu, Lagos and Port Harcourt and for meeting the standard of South Korea railroads and roadways. Nigerian government should encourage Public Private Partnership PPP to advance the infrastructural development of railroad and roadway in Nigerian cities. The investors should be allowed to build toll gates on the federal expressways and charge fees on each vehicle to recoup the invested amount and to make a profit. The entire federal expressway should be dualized with several lanes on both sides just like South Korea.

The existing trains and buses cannot serve the population of passengers and freight thus the need for more advanced trains and buses to improve movement of people and goods. New railroads and roadways should be constructed to meet the transportation need of the growing Nigerian population. The obsolete railroads running on single track should be rehabilitated and expanded to the dual track to enable round trip of the train on a route at the same time. Speed trains of at least 201km/h should be introduced while the current 45km/h trains should be discontinued.

The Nigeria railroad sector should be privatized to allow private companies invest in the sector, the monopoly of the sector by NRC should be discontinued. The local roads and State highways require more fund for pavement and rehabilitation than the federal expressway as both contributes 84% of Nigeria roadways and have 87% and 78% of poor road conditions respectively. Nigeria infrastructural development should be based on the economic viability of the region not based on politics or favoritism. More railroads should be constructed in the Southern part of Nigeria which has only 34% of the total railroad extension in Nigeria as shown in the findings.

Finally, Nigeria transportation sector is in a bad state and requires urgent attention by the authorities to improve the infrastructure in other to meet the transportation demand of Nigeria growing population. A new design has been proposed for Abuja, Enugu, Lagos and Port Harcourt railroads and roadways, these include expansion of the single carriage into dual carriage, rehabilitation of bad and poor roads, construction of new routes, building of toll gates, replacement of single rail track to double rail track, changing of narrow gauge to standard gauge and replacement of old locomotive trains with more advanced one. The proposed new railroad for Abuja, Enugu,

Lagos and Port Harcourt will cost about US$(77,217,065,390) and roadway will cost US$(614,962,329) to implement.

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