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## Evaluation of Technical Innovations in Bus Rapid Transit System in Lagos State, Nigeria

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### Authors' contributions

*This work was carried out in collaboration between all the authors. Author DEA granted the approval for the data collection, reviewed the final manuscript. Author JBA supervised the collations, interpretation and initial dissertation. Author OFD managed the field data collection and analysis. All the authors approved the final manuscript.*

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### ABSTRACT

Lagos state is one of the largest cities in the world with an estimated population of 18,000,000 on a land mass of 3,577 sqkm. Urban mobility, Road traffic and congestion have been major challenges in the State for many years; The Bus Rapid Transit (BRT) scheme was introduced to help alleviate these problems. In the light of this, the technical innovation in the operation of the Bus Rapid Transit (BRT) system in Lagos State was evaluated and the outcome of the evaluation was compared with international BRT standards. Data was collected through guided oral interview with the use of questionnaire. Also, secondary data was used. Results showed that the introduction of BRT system in Lagos State is still at its pilot phase of operation but gradually advancing to BRT Classic which is the full operational BRT System of international standard. Presently, existing BRT innovation in Lagos includes BRT terminals and stations, dedicated lanes and bilateral stations, on-going median stations, provision of coloured delineators and colorized pavement on intersections

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as well as creation of space for BRT depots and terminals. The paper concluded that there is need for further improvement on the existing Lagos State BRT standard so that it will be able to compare well with International BRT standards.

*Keywords: Bus rapid transit; transport; urban; operations; satisfaction; commuters; Lagos.*

## 1. INTRODUCTION

Lagos is the largest city in sub-saharan Africa (SSA) and the sixth largest city in the world, with a population of over 18 million, and growing at 6 percent per annum [1]. It contains the largest manufacturing sector in the country and provides employment for over 45 percent of the skilled manpower of the country. Over the last twenty years, efficiency and productivity levels in the metropolitan area have been adversely affected by the growing weaknesses in the physical infrastructure necessary to support the basic needs of the population and the productivity sectors such as the transport infrastructure.

Transport infrastructure and services remain at levels that supported a population of no more than 6 million some 20 years ago [1]. The public transport network density, about 0.4 km/1000 population, is quite low even by African standards [1]. The provision of bus public transport is highly fragmented with minimal fleet operations; instead private individuals operate many mini buses of poor quality and in an undisciplined fashion [1]. Despite the size of the city, there are no organised mass transit systems nor is the inland water-way system exploited to offer alternative non-road based commuter services [1]. Transport costs to users constitute a high proportion of disposable income [1], and unsurprisingly, congestion is a major issue in the city affecting significantly the costs of production [1]. While Lagos is no longer the federal or state capital, its role as gateway to the country is still unquestioned [1]. Evidently from the role of Lagos State as a major gateway to the nation, the associated transport inadequacies calls for a strategy for its management.

Lagos is not only congested but also has the problems associated with urban congestions such as road traffic and absence of parking space [1]. Rapid growth of the private vehicle fleet, combined with reliance on commercial vehicles and motorcycles (molues, danfo, taxis, okada etc.) has resulted in extreme traffic congestion throughout the city, and poor quality public transport [2]. Until recently, public transport in Lagos could be described as

unregulated, chaotic, inefficient, expensive, low quality and dangerous, both in terms of road traffic accidents and personal safety [2]. There are about 2,600 km of roads in Lagos that are frequently congested, with over 1 million vehicles plying the roads on a daily basis [2]. A recent study showed that there were 222 vehicles per kilometer in Lagos, which by far outweighs the national average of just 11 vehicles per kilometer of road [2].

In order to provide consistent transport policy planning and efficient implementation of the policies and ameliorate the deplorable traffic situation in the State, the Lagos State government established the Lagos Metropolitan Area Transport Authority (LAMATA) in 2003 as the executive agency of the Lagos Urban Transport Project (LUTP). LAMATA was invested with the overall role of coordinating the transport policies, programmes and actions of all transport - related agencies and of implementing and managing public transport services in the Lagos metropolitan area. The 'Bus Rapid Transit (BRT) scheme' is one of the flagship programmes of LAMATA [3].

The Lagos State BRT scheme became operational on 17<sup>th</sup> March 2008. It is focused upon delivering a system to meet key local users needs, with the aim of improving quality of life, economic efficiency and safety within a clearly defined budget [3]. BRT was established in the State to improve transportation with specific operational and economic goals. The promotion of Bus Rapid Transit (BRT) is a veritable option directed at improving the service delivery in the public passenger transport particularly as it affects the most predominant form of transport mode in Nigeria – road transport. The essence is to relieve congestion, enhance mobility, and improve the environment especially with regard to pollution in the Lagos metropolis [4]. After several years of operation, it is imperative to assess the technical innovations in the BRT system in Lagos State and compare the outcome of the evaluation with what is obtainable internationally.

### 1.1 The Concept Bus Rapid Transit (BRT)

According to the U.S. Federal Transit Administration (FTA), most important technical innovations in the transport sector involve the way bus services are operated and the infrastructure used to optimize their speed, comfort, and capacity. In view of this, they helped to popularize a term for such measures which is the Bus Rapid Transit, or BRT.

*BRT Implementation Guidelines* defined BRT as: "A flexible, high performance rapid transit mode that combines a variety of physical, operating and system elements into a permanently

integrated system with a quality image and unique identity" [5].

Wright and Lewis [6], defines it as a "bus-based mass transit system that delivers fast, comfortable, and cost-effective urban mobility".

Levinson et al. [7], previously defined BRT as "a flexible, rubber-tired rapid-transit mode that combines stations, vehicles, services, running ways, and Intelligent Transportation System (ITS) elements into an integrated system with a strong positive identity that evokes a unique image".

**Table 1. Components or features of BRT system**

Components	Levinson et al. [7]	Wright and Lewis
Running ways	BRT vehicles operate primarily in fast and easily identifiable exclusive transit-ways or dedicated bus lanes. Vehicles may also operate in general traffic.	Exclusive right-of-way lanes.
Stations	BRT stations, ranging from enhanced shelters to large transit centers, are attractive and easily accessible. They are also conveniently located and integrated into the community they serve.	Rapid boarding and alighting. Enclosed stations that are safe and comfortable.
Vehicles	BRT uses rubber-tired vehicles that are easy to board and comfortable to ride. Quiet, high-capacity vehicles carry many people and use clean fuels to protect the environment.	Clean vehicle technologies
Services	BRT's high-frequency, all-day service means less waiting and no need to consult schedules. The integration of local and express service can reduce long-distance travel times.	Excellence in marketing and customer service.
Route Structure	BRT uses simple, often colour-coded routes. They can be laid out to provide direct, no-transfer rides to multiple destinations.	
Fare Collection	Simple BRT fare collection systems make it fast and easy to pay, often before you even get on the bus. They allow multiple door boarding, reducing time in stations.	Pre-board fare collection and fare verification.
ITS	BRT uses advanced digital technologies that improve customer convenience, speed, reliability, and operations safety.	Clear route maps, signage, and real-time information displays. Automatic vehicle location technology to manage vehicle movements.
Integration		Free transfers between lines. Modal integration at stations and terminals.
Institutional setup		Competitively-bid concessions for operations. Effective reform of the existing institutional structures for public transit.

Source: Ernst [8]

## 2. METHODOLOGY

The study was conducted in Lagos State and covered the following areas: Lagos Metropolitan Area Transport Authority (LAMATA) office (Agency of the Lagos State Ministry of Transport responsible for the administration of the BRT System) and major BRT corridors and terminals in Lagos State. Primary sources of data collection included guided oral interview schedules with the use of questionnaire. Three heads of department in LAMATA were interviewed to elicit information on the technical innovations in the Lagos State BRT system. Also, corridors and routes were visited to carry out personal investigation and findings. Secondary data was collected from documents, text books, journals, magazines, and other relevant publications on the study. The study compared the outcome of the evaluation with international BRT standards using BRT Standard Version 2.0.

## 3. RESULTS AND DISCUSSION

### 3.1 Technical Innovations in the BRT System in Lagos State

Result of the guided interview and questionnaire administration conducted at Lagos State Metropolitan Area Transport Authority (LAMATA) office on the technical innovations (operations and infrastructure) in the Lagos State BRT system are explained under the following headings:

### 3.2 Operations

#### 3.2.1 Phases of execution of BRT system

Execution of BRT system in Lagos has been phased into:

1. The BRT-Lite: This is the ongoing BRT system in Lagos State which is the pilot phase. This is to enable LAMATA understand operational and infrastructural challenges and be better prepared for the implementation of full BRT system which is the BRT classic phase.
2. BRT classic: The BRT classic phase is the full BRT system with the following facilities fully implemented;

- Automated transport system with signal;

- Electronic payment system;
- Control station;
- Passenger's information system.

#### 3.2.2 BRT partnership

It was revealed from the interview that there exists a Public Private Partnership (PPP) system for BRT in Lagos although it is in a form of franchise. The major corridors for this PPP operation are Mile 12-TBS, Maryland-Ikeja-Iyana Ipaja, Iyana-Ipaja-Ikotun-Igando, Ikeja-Igando-Ikotun.

Lagos State BRT adopted the Landlord model form of PPP. That is, LAMATA owns infrastructure, depots, routes and shelters while operators only own the buses and obtain the franchise (Legal right) to operate in specified routes. Procurement of buses is financed by Eco Bank, and in order to secure their investments, the bank is also responsible for the printing of fare tickets. These tickets are sold to appointed ticket dealers who pay in cash. The ticket dealers now sell the tickets to commuters at the BRT terminals/stations. Risk associated with ticketing is solely on ticket dealers since they remit fund to the bank on purchase. Maintenance is being carried out by Motor operators which involve the: National Union of Road Transport Workers (NURTW). NURTW Cooperative is the first BRT cooperative responsible for maintenance of BRT buses. There is also an operational arrangement between LAMATA and the PPP for LAMATA personnel staff to regularly organize capacity building workshops for BRT operators so as to ensure the efficiency and effectiveness of the BRT transport system. The functions of these personnel staff are:

- i. To create time table for buses;
- ii. To create time table for crew members;
- iii. Proper record keeping in order to generate history.
- iv. Data collection
- v. To monitor all activities at the BRT terminals.

#### 3.2.3 Choice of corridor/routes

The factors listed below were considered by Lagos State government at the inception of the BRT system for the selection of the route of operation.

- a. Traffic congestion
- b. Population mobility threshold – Movement of people in the area in terms of ridership.

- c. Road network of routes: This refers to linkage with other areas in terms of accessibility.
- d. Detailed feasibility study.

### **3.3 Infrastructure**

#### **3.3.1 General infrastructure**

The major BRT corridors at present are Mile 12-TBS, Maryland-Ikeja-Iyana Ipaja, Iyana Ipaja-Ikotun-Igando, Ikeja-Igando-Ikotun.

The Facilities introduced in the construction of these corridors are:

- a. Creation of BRT Terminals and Stations
- b. Bilateral stations at Mile 12 – CMS route
- c. Ongoing Median stations at Mile 12-Ikorodu route
- d. Construction of dedicated lanes with slight barrier to form segregated right of way (Mile 12 –TBS)
- e. Provision of coloured delineators (yellow road markers) to segregate BRT lanes (Berger-Third Mainland Bridge-Obalende route.
- f. Colorised pavement on intersections to facilitate lane change and to warn other motorists of incoming BRT buses.
- g. Creation of space for BRT depots and terminals.

#### **3.3.2 Depot/Station/Terminal design**

Innovations introduced in the operation and design of the BRT depots/ terminals and stations:

The existing BRT depots, as at the time of this research, were innovatively born in the cause of searching for space, which is a limited resource in Lagos state. Areas under flyovers which were strategically located in Lagos were successfully converted into BRT depots and terminal. This has innovatively spread to other agencies across Lagos State, such as MOE (Ministry of Environment). Unutilized spaces under many flyovers in Lagos state are now used as parks, e.g. Mile 12 terminal.

A close section of the terminal is provided for elderly people to relax while waiting for bus to arrive; Shelters are put in place to protect against weather; guarded rails are constructed to enforce

orderliness in entering the buses and protect against accidents.

#### **3.3.3 Platform design**

Concrete platforms were designed and constructed at every terminal and stations to facilitate easy boarding of buses.

#### **3.3.4 Choice of buses**

It was discovered from the survey that the platform design for Lagos State BRT buses are not low level platform buses, rather they are high level platform buses and this makes it difficult for users with physical disability and senior citizens to access the BRT buses.

High level platform buses, according to LAMATA, are more suitable to our weather conditions in Nigeria, particularly Lagos State. It was further explained that if low level buses are used, during rainy season water will enter the bus in areas prone to flooding, such as Iyana ipaja, Ikotun, etc. Furthermore, sitting comfort; two doors for easy entrance and exit; and adequate ventilation were cited as added advantages in procuring high level platform buses.

#### **3.3.5 Choice of payment systems**

According to the study, the choice of ticketing system adopted in the operation of Lagos State BRT is the paper ticketing system. Revenue security, fare stabilisation, data collection and proper zone billing were reasons cited for adopting the paper ticketing system. The study also showed that there are no other designated spots where boarding tickets can be purchased aside the BRT terminals/stations. This is a security measure to protect the ticketing system against forgery and it is further reinforced by contracting printing of tickets solely to a security printing company certified by CBN. Again, only accredited dealers can buy tickets from the bank. According to LAMATA, as at the time of this study, there is an ongoing planned upgrade/innovation on the ticketing system to the Electronic Ticketing System. The benefits of the intended upgrade over the existing ones are: increased mobility, maximum revenue security, opportunity for users to pay per distance covered as against current flat rate. Its objective is to make it twenty naira from one shelter to the next.



**Fig. 1.1. Map showing BRT LITE bus stops in Lagos State**  
 Source: Field survey (LAMATA 2013)

**3.3.6 Branding**

The findings from the study showed that the bodies of the BRT buses as a form of added innovation, are being used for advertisement (product posters and banners displayed on the buses) in order to generate additional income and add beauty to the body of the buses.

**3.3.7 Integration with other public transport**

The Lagos State BRT system integrates with other public transport through the availability of more than enough feeder/connecting roads which enables multi-connectivity and ease of access.

**3.4 Comparison of Lagos State BRT with BRT Standard (Version 1.0)**

The BRT Standard is an effort by leading technical experts to come to a common understanding of what constitutes internationally recognized best practice in BRT system design. The best BRT systems are ones that combine efficiency and sustainability with passenger

comfort and convenience. The BRT Standard uses design characteristics that act as proxies for enhanced performance and customer experience. This scoring method celebrates high-quality BRTs, but is not intended to denigrate lighter BRT improvements which may also yield important benefits to customers (BRT International Standard, 2012).

The BRT Standard provides a framework for system designers, decision makers, and the sustainable transport community to implement and identify top-quality BRT systems. It measures how closely a proposed or existing system resembles best practice. Version 1.0 of the BRT Standard is the culmination of a review by the BRT Standard Committee undertaken during 2011. The BRT Standard Committee is a selected group of leading BRT experts that have worked on many of the world’s best BRT systems [9].

The BRT Standard is necessary for recognizing higher-quality systems on a comparable basis in addition to performance based analysis. Attempts to reliably collect data across a wide variety of systems and compare them in a

manner that fairly rewards the better performers have simply proved fruitless to date. The measures included in the BRT Standard will almost always tend to improve performance if the corridor is designed properly for the ridership. If a system or corridor, however, is poorly designed, there is a risk that the BRT system could saturate and congest, reducing bus operating speeds and making conditions worse for passengers. To mitigate the risk of conferring a quality brand on a system with good BRT elements but improper sizing, management, or regulations, the BRT standard committee decided to assign a limited number of penalty points applicable for already-operational systems where some readily-observable baseline performance metrics were not met. The BRT Standard has been developed to weigh all BRT systems according to the same criteria rather than relative to a system's demand or a city's population. It does not differentiate based on high-demand, medium-demand, and low-demand BRT systems. The purpose of the BRT Standard is to create one definition of international best practice [9].

Ultimately, the BRT Standard has two main uses:

1. To evaluate systems already built to recognize those systems that are of the highest quality.
2. To be used by planners, decision makers, and concerned citizens as a way to evaluate BRT corridors in the planning phase. It will function as a mechanism to understand how close plans come to international best practice and to illuminate where changes could be made to improve the system [9].

The BRT International Standard classified existing systems as Gold (the highest rating), Silver or Bronze based on complex series of scoring as a result of point addition or point deductions by categories.

In order to effectively evaluate the quality of Lagos State BRT system and to illuminate where changes could be made to improve this existing system, this section compares the existing structure with internationally accepted standard using the under-listed categories.

#### **3.4.1 Off-board fare collection**

Off-Board Fare Collection is one of the most important factors in reducing travel time and improving the customer experience. There are two basic approaches to the off-board fare

collection; i. Barrier controlled ii. Proof of payment.

##### **3.4.1.1 Barrier controlled**

Passengers pass through a gate or through a check point where their fare is deducted or verified.

##### **3.4.1.2 Proof of payment**

Passengers pay and obtain paper ticket beforehand, which is then checked on board or on entering the vehicle by an inspector.

By BRT International Standard, a BRT system has the highest rating under this category when all the trunk stations have adopted the barrier controlled system off-vehicle fare collection. The Lagos State BRT system adopted the proof of payment system on all routes that run on the trunk corridors which is rated as the second best by international standard.

#### **3.4.2 Multiple routes**

Multiple routes can be defined as the existence of two or more routes on a corridor. Having multiple routes operating over multiple corridors or on a single corridor to different destinations is a major flexibility of a bus based system and one of the primary advantages is of the BRT. However International BRT standard suggests the existence of multiple routes on a corridor servicing at least two stations as the best. The Lagos state BRT system has adopted this method and could be ranked best in this regard.

#### **3.4.3 Control center**

A full service control centre monitors the location of all buses with GPS or similar technology, responds to incidents in real time, controls the spacing of buses, knows the maintenance status of all buses in the fleets, and for future service adjustments. A full-service center should be integrated with a public transport system's existing control centre, if it exists, as well as the traffic signal system.

Lagos State BRT does not have a control centre and hence the above named services are not available.

#### **3.4.4 Corridor location**

If the BRT corridor is located along one of the top ten corridors in terms of aggregate bus ridership,



this will help ensure a significant proportion of passengers benefit from the improvements. Traffic congestion, population mobility threshold, and road network of routes are factors considered by Lagos State government to determine choice of corridor and routes. Hence, Lagos state BRT operates in all top demand corridors.

#### **3.4.5 Hours of operation**

A viable transit service must be available to passengers for as many hours as possible throughout the day and week. Otherwise passengers could end up stranded or may take another mode. This includes late night service, just before midnight and weekend services in addition to all week day services.

According to BRT International Standard, BRT with both late night and weekend service is rated highest. Lagos State BRT operates between the hour of 6 am and 8 pm without late night and weekend services.

#### **3.4.6 Bus way alignment**

The bus way is best located where conflict with other traffic can be minimised especially from turning movement from mixed-traffic lanes. By international standard, two-way median aligned bus ways that are in the central verge of a two-way road is best for BRT because this encounters fewer conflicts with turning vehicles than those close to the curb. Vehicles and taxis require access to the curb, the central verge of the road usually remains free of such obstructions. Except for the Ikorodu bus-ways that are split into two one-way pair but are centrally aligned in the road way (ongoing median station), most other corridor configurations of the Lagos State BRT are bus-ways that are split into two one-way pairs aligned to the curb. Under this category, the International Standard deemed the two-way median-aligned bus ways that are in the central verge of a two-way road the best.

#### **3.4.7 Segregated right of way**

A segregated right of way is vital to ensuring that buses can move quickly and unimpeded by congestion. Enforcement of the dedicated lanes can be handled in different ways with varying degree of permeability. Delineators act as slight barriers that need enforcement to be effective. Full segregation means that the lane is physically protected, thus self-enforcing. Colorization acts

as a visual delineator only. By BRT International Standard, the type of segregated right of way with delineators and colorization and or full segregation applied to over 90% of the bus way corridor length is the highest standard.

Lagos State BRT has delineators, colorizations and or full segregations applied to major corridors. However, there is a need to apply this to over 90% of its corridor to make it comply with the international standard.

#### **3.4.8 Intersection treatment**

Intersection treatments are ways aimed at increasing bus speed at intersections. For example, forbidden turns across the bus lane and traffic signal priorities when activated by an approaching BRT vehicle are the most important.

On major corridors of Lagos State BRT, intersections and diversions are marked in yellow carpets to warn motorists of the total right of way of incoming BRT buses. Motorists are forbidden to wait on or obstruct the marked area. Under this category, intersection treatment of this type by Lagos State BRT is rated amongst the best by International Standard.

### **4. CONCLUSION AND RECOMMENDATION**

The technical innovations (operation and infrastructure) provided in the Bus Rapid Transit system in Lagos State in the course of finding a lasting solution to the challenges facing urban passenger transportation in the state is highly ground-breaking, but there is a need for further improvement on the existing standard so that it will be able to compare well with what is obtainable in the advance economy where BRT has been in operation.

Based on the findings and conclusion of this work, in order for Lagos State BRT system to meet up with international standards and migrate to BRT classic, the following recommendations are advised.

- Introduction of a barrier controlled off-board collection process where passengers will pass through a gate or through a check point where the fare is deducted or verified.
- Construction of a full service control centre that monitors the location of BRT buses,



knows the maintenance status of all buses in the fleet, and for future service adjustments.

- Lagos State BRT needs to be available to passengers for as many hours as possible throughout the day and week. This includes late night service and weekend services.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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## APPENDIX 1

### QUESTIONNAIRE

**AFRICAN INSTITUTE FOR SCIENCE POLICY AND INNOVATION (AISPI),  
FACULTY OF TECHNOLOGY, OBAFEMI AWOLowo UNIVERSITY, ILE-IFE, NIGERIA**

#### QUESTIONNAIRE FOR LAMATA OFFICE

***Dear Respondent,***

This research is aimed at **Assessing the Technical Innovations in Bus Rapid Transit System in Lagos State** with a view to making policy recommendations that would improve and sustain transport system in the State.

Kindly spare some time to complete the questionnaire. Provision of accurate information by you would immensely contribute to the success of the study. Please tick (✓) in the boxes or write in the spaces provided as may be appropriate.

**Thank you Sir/Madam in great anticipation of your kind assistance in this regard.**

#### **SECTION A: Technical Innovations in the BRT System.**

1. How many traffic corridors / routes do you have presently and what are their names? (any document /map that shows the various corridors?)

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2. What are the factors that influence your choice of routes?

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3. In the construction of the corridors, what innovations or technology were the deciding factors?

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4. The BRT in Lagos State took off with the BRT-Lite, Kindly shed light on the phases of execution as it evolved into full BRT system.

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5. What are the differences between the blue and the red buses?

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6. The Public Private partnership (PPP) was introduced as a as a form of franchise in the operation of the BRT,

a. What are the corridors and routes they operate?

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b. What are the rules guiding the PPP?

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c. Are they responsible for procurement or maintenance?

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d. What are the operational arrangements between LAMATA and the PPP?

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7. What are the innovations introduced in the design of the BRT terminals and stations?

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b. Why are these innovations introduced?

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8. What are the factors that influenced the design of the BRT Stations?

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b. What are the functions of the infrastructures in the stations?

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9. Are there any infrastructures or design at the stations that make boarding easy for users?

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10. Are there facilities (on the vehicles or at the terminals) designed to inform users of the various route, stations and bus stops (e.g. real time next bus stop sign, next bus arrival sign at the station)?

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11. There are several vehicles you could use such as low level platform vehicles, why did you choose the present type of vehicles in use?

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b. What are the advantages of these vehicles?

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12. Your choice of payment is the paper ticketing system, why did you prefer that?

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b. Are there other designated spots where boarding tickets can be purchased aside the BRT terminals/stations? Yes / No

c. What are the security measures to protect the ticketing system against forgery?

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d. Is there any planned upgrade or improvement to the ticketing system? Yes/No

e. If yes, what are the benefits of the intended upgrade over the existing one?

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13. Kindly describe the innovative road signage in the Lagos BRT system apart from the normal existing one?

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14. Are there boarding facilities in any of the BRT station/ terminal that makes the following users to easily assess the BRT buses? Yes/No

a. Users with physical disability

b. Senior citizens (people over 70 or 80 years of age)

c. If the answer to a&b above is yes, what are the available boarding facilities?

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15. What is the policy regarding the body of the BRT buses being used for advertisement? e.g. product posters and banners displayed on the buses. Is this a new innovation?

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16. In what ways does the BRT system integrate with other public transport in Lagos State?

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Thank you for sparing your time.

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