

# PUBLIC TRANSPORT INITIATIVES IN WEST AFRICA, A CASE STUDY OF ABIDJAN

Leonard Johnstone<sup>1</sup> and Vatanavongs Ratanavaraha<sup>2</sup>

<sup>1,2</sup>Institute of Engineering, Suranaree University of Technology, Thailand

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**ABSTRACT:** Abidjan is the principal city of the West African Republic of Côte d'Ivoire. It is the gateway city to West Africa. In 2014, the population of the city was estimated at four million people. Over the next fifteen years, this is projected to rise to nearly seven and a half million people. This continuing growth has an associated projected strong economic growth. This paper addresses the challenges associated with the provision of equitable public transport services to address the needs of the growing population. Public transport currently in Abidjan is complex consisting of both formal transport in the form of public bus services and several forms of informal public transport. In order to understand the existing travel trends and especially the declining public transport proportion in Abidjan, a series of surveys were undertaken for the development of an analytical methodology. This included amongst others an interview survey of people at the household level and public transport opinion surveys. The methodology thus developed allowed an understanding of the impact of new proposed infrastructure. The introduction of new infrastructure in the form of a higher level of public transport and an enhanced regulatory format will enable the implementation of an environmentally friendly public transport with a growing market share.

*Keywords: Public Transport, Côte d'Ivoire, Mode Split, Environment*

## 1. INTRODUCTION

Abidjan is a city of lagoons and parks, a colorful city of blue as represented in Fig. 1 also highlighting the significant administrative boundaries. The Abidjan vision and long-term city development are based around three main goals of transportation system enhancement namely:

- Efficiency;
- Equity, and
- Better Environment.

An efficient transportation system should be developed to strengthen urban functions, to enhance people's quality of life, to facilitate economic activities, and to sustain stable economic growth in Abidjan. It is of great significance to achieve efficiency by decreasing negative externalities such as economic loss of travel time caused by increasing traffic. The efficiency in transportation is achievable by balancing the growing travel demand within the city and the transportation infrastructure supply.

An enhanced transport system with a diversion from the private to the public leads to a better green environment in a similar structure as with the diversion of cargo to green cargo transport[1].

There are three ways to balance the demand and the supply: 1) by increasing and recovering the infrastructure capacity to meet the demand; 2) by optimizing utilization of the existing transport infrastructure through efficient transportation control

measures; and 3) by decreasing excessive vehicular traffic demand through transportation demand management and diverting private vehicle users to public transport.

Equity means that a certain minimum level of mobility should be assured and provided for all members of society. Not only automobiles but also all modes of transport should have a right to share the public space and move around the city freely and safely.

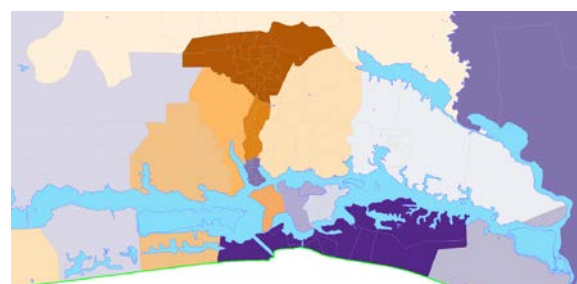


Fig. 1 The city of lagoons.

On the other hand, some low-income people cannot afford to pay for expensive transportation costs. Some socially vulnerable people including the aged and the handicapped have difficulties in their mobility. Affordable and sufficient level of transportation services should be provided for those people especially by the improvement of the public transport system.

The vision for Greater Abidjan is about, "providing quality living environments," air

pollution and noises caused by automobiles should be minimized by promoting public transport use and controlling the traffic demand. At the same time, air pollution and noise should be reduced by applying stricter vehicle emission standards to reduce air pollutant emissions and this is enshrined in the Paris climate accords [2].

The city of Abidjan is divided into administrative regions or communes. These communes serve in addition as boundaries for physical transportation. In some incidences, there is modal restriction between communes. Some modes of the informal transportation system are not allowed to enter certain communes or there is restricted travel between communes.

## 2. THE CURRENT SITUATION

During the year, 2013, there was an update of the Abidjan transport master plan [3]. Significant surveys were undertaken during this revision including detailed public transport and home interview surveys. The home interview survey sample size was a little over two percent of all households in Abidjan. Some 20,000 households were included in the survey.

One key result from the survey was the confirmation of the importance of both the walk mode and the informal transport sector in the city namely in the form of the Woro-woro and Gbaka as reported in Table 1. The private or car mode is still relatively low but significant growth has been seen in this mode.

As these informal public transport modes are likely unfamiliar, photos of the vehicles associated with these informal modes are provided in Fig 2. The commonly used Gbakas service is provided by minibus vehicles with a capacity of between 14 and 32 seats, and are subject to transport authorization issued by the government for a particular line of operation.

Table 1 City wide modal distribution of traffic

Mode	Percentage
Walk	53
Car	5
Taxi with meter	2
Woro-woro	20
Gbaka	11
Bus	6
Oher	3
Total	100

During the review of the transport master plan study[3], it was estimated that there were 2,900 Gbakas operational during a single day. They may operate anywhere with the exception of the central

business area, the commune of the Plateau.

The Woro-woro or intra-communal taxis are required to perform local services of proximity existed for several years. They have developed significantly in recent years due to some of their competitiveness compared to other modes, and secondly thanks to the shortage in supply of Buses available to the public transport company. Whilst there are some arguments for the desirability [4] of the informal sector, it does not meet the aspiration associated with the overall improvement of public transport in the city.



Fig. 2 Informal transport modes.

### 2.1 Historical Activity Levels

These informal modes of transport have risen in percentage terms in recent times by providing a desired service to the public. The public bus service company locally referred to as SOTRA(Société des transports Abidjanais) has seen its ridership fall from a peak of 700,000 passengers per day to 400,000, a decline of forty percent as depicted in Fig 3.

In 1998[5], the modal share of non- walk trips for SOTRA bus was twenty-four percent with Gbaka accounting for a further twenty-five percent whilst seventeen percent of trips were made by Woro-woro. By 2013, the modal proportion of bus and Woro-woro was reversed as reported in Table 2. Woro-woro then accounted for thirty- two percent of mechanized person trips with public bus accounting for a reduced mode split of only twelve percent.

The earlier studies on urban transport conducted revealed a total of 2.2 million person trips per day for the inhabitants of Abidjan who at the time were more than 8 years old in the inner communes. Public

transit at that time consisted of a healthy share of around fifty percent consisting of both the bus and Gbaka.

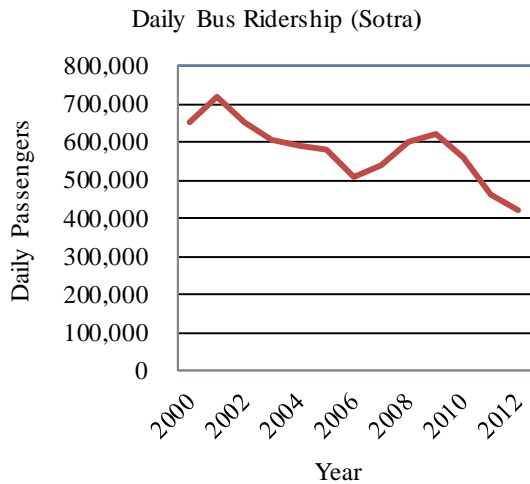


Fig. 3 Public bus patronage

The mode split within other selected major African cities is reported in Fig 4. Although the informal modal share of mechanized trips is high in other African cities [6], only Abidjan with an informal modal share of nearly fifty percent is in comparison with other African cities such as Accra and Dar Es Salam.

Table 2 Historical mode split of motorized travel

Mode	Percentage	
	1998	2013
Private (Car and Motorcycle)	14.0	11.7
SOTRA	24.0	11.7
Gbaka	25.0	25.1
Woro-Woro	17.0	31.7
Meter Taxi	16.0	17.5
Employee Bus	4.0	2.3
Total	100.0	100.0

It must be admitted that the physical city landscape is not so attractive to the provision of long bus routes and could be considered more conducive to the informal sector with an emphasis on shorter trips.

The landscape of the Abidjan District is punctuated by many valleys called thalwegs, surrounded by very steep slopes that are not even conducive to a good road system.

The thalwegs create natural boundaries to quarters and are most of the time uninhabited as people are reluctant to live in those areas that are used as illegal landfill and can be flooded instantly

during raining days. Planners have used this free space to design roads inside those thalwegs as the land was available.

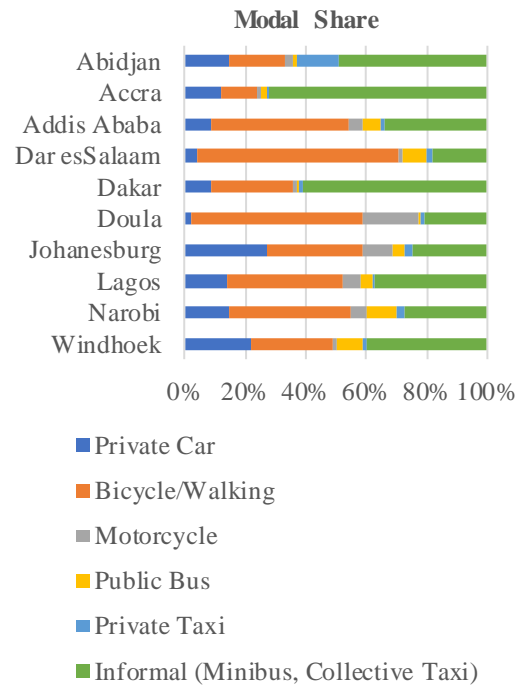


Fig. 4 Public transport city modal share

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## 2.2 The Urban Structure Today

In administration terms, Abidjan, as previously mentioned is divided into communes. The key inner communes are depicted in Fig. 5 which also are proposed for future transit connectivity. The Plateau commune functions as the central area of the city with the communes of Adjame and Abobo to the north. Whilst in the west of the city there are the communes of Attécoubé and Yopougon. In the east, there are the communes of Cocody and Bingerville.

In the south, north of the southern waterway are the communes of Treichville, Marcory, and Koumassi. Then there are the communes of Port Bouet and Grand Bassam. The later two communes border the Atlantic Ocean.

The road network has been mainly developed

without any consideration of Public Transport. Although public transport has been declining in recent years as discussed earlier, the proposals of the updated master plan 2030 have as one of its main objective a restoration the credibility of public transport lost during the previous ten years.

In order to integrate public transport inside the road network, and in particular a mass-transit system, the first step is to secure sufficient space for both road users and public transport facilities along the targeted roads.

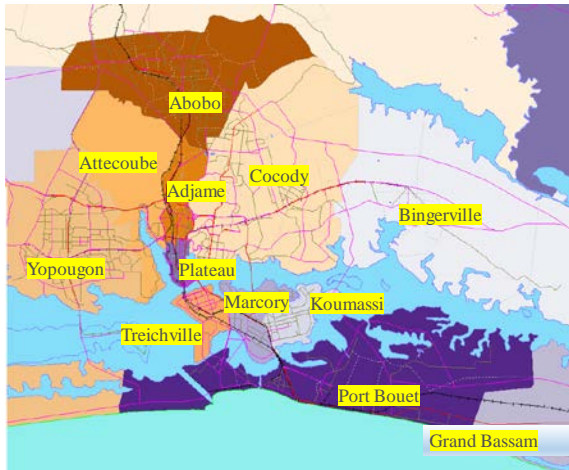


Fig. 5 The inner communes

Around Abidjan, fast urban development can be seen, in particular between Cocody and Bingerville where large residential areas have been built at a very fast pace. To meet the growing demands in habitation, large residential areas are under development. The transport master plan and thus the road master plan must take into account all this latest urban development to ensure consistency between land use and infrastructure development with respect to the infrastructure network.

As the main roads have a high capacity, many private vehicles take the primary urban roads. Moreover, since the primary urban roads connect the major industrial areas in Abidjan such as Yopougon, Treichville, and Koumassi, via the primary urban roads to Abidjan Port and other major cities in Cote d'Ivoire, these roads also serve as a freight transportation corridor.

Based on the result of the traffic count surveys undertaken during the master plan review, compositions of trucks to all traffic are documented, and the major truck routes have been identified as part of this analysis. The access from the northwest and the west can be regarded as the heavy vehicle corridors serving as well connectivity for local traffic.

Some key issues are:

- Congestion points around the central area or Plateau;
- Absence of any high capacity public transport such as a metro system (previously recommended but never constructed) or Bus Rapid Transit;
- Limited access routes to the Plateau which is likely to grow in importance;
- Residents in new developments areas in Abobo and Yopougon(both expected to attract an additional one million people over the next two decades) must access the Pateau in a north-south movement. There is no direct east-west link from central Yopougon to the Plateau; and
- Dependence on the private car and informal public transport.

The key planning issues for public transport is that the public transport service is currently provided largely by the informal sector. Bus services are concentrated on routes originating from suburban areas and ending in several city terminals such as Adjame or the Plateau terminal. The informal sector accounting for eighty-five percent of public transport trips is provided via the following modes:

- Gbaka;
- Intra Communal Taxis or Woro-woro;
- Inter Communal Taxis;
- Fixed Route Taxis; and
- Meter Taxis.

Bus routes are often categorized into four types from a planning point of view, namely, line-haul bus services on high capacity corridors, circulator bus services within major centers such as the central area, circumferential routes and suburban feeder bus services. Alternatively, one may consider three levels of public transport namely a primary, secondary and tertiary level. With both the circulator and feeder services set into the later category.

The circumferential routes would provide linkages between major activity hubs without the need for coming into the center to access an adjacent hub. The viability of a bus route re- structure needs consideration in light of existing and future travel demand. Thus a methodology or a tool is needed to understand the impact of future demand in relation to the proposed future land use planning in order to ensure the maintenance of the earlier specified transport goals.

The analysis needs to define a role for all the city transport modes. Most line haul routes can become the prerogative of the formal public transport structure. The role of the informal sector such as Gbaka, Intra Communal Taxi or Woro-woro then



focuses on Circulator and Feeder routes and possibly the need or otherwise for circumferential routes. Whilst it is common to have a circular route in the central area, in Abidjan consideration should be given as well for the need for such routes within the individual communes.

### 3. METHODOLOGY

A classic four step transport model is developed as the analytical tool for the understanding of the movement of the people throughout the city as depicted in Fig. 6.

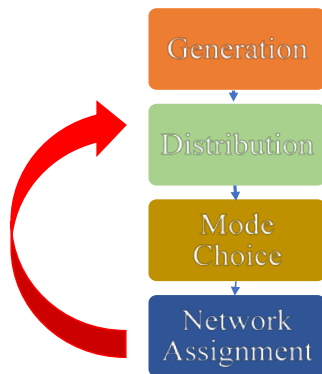


Fig. 6 The city model structure.

The first step is to address the starting and ending point of each person trip. The number of trips generated in each small area or traffic zones is linked to socio-economic characteristics. In this analysis, the city of Abidjan was divided into 168 traffic zones.

The second step is the distribution of trips throughout the city. This distribution is linked to the impedance of travel between any two traffic zones. whilst the third step, the focus of this project, is the assignment of the person trip to the various walk, private or public transport mode. The public transport mode is then split into the formal and informal sector. This modal choice considers the cost of travel between any two traffic zones.

The network assignment combines all movement across all transport network infrastructure and thus provides an understanding of the movement of people including the priority and type of infrastructure proposals[7]. The focus of this research paper is on the movement of people and the probability of modal shift.

#### 3.1 Data Preparation

The base input data are a collation of databases available from the detailed survey program undertaken during the Abidjan master plan with particular reference to the aforementioned extensive

home interview survey. In the model development, a master transport network is first prepared that includes all known and proposed transport projects with specific reference to public transport proposals.

#### 3.2 Key Inputs – The Drivers Of Future Demand

The key planning inputs are the distribution by small area or traffic zone of population, household, employment, student enrolments, and household income. The population of Abidjan is predicted to grow from 5.8 million in 2015 to 8.8 million in 2030 whilst the city economic growth is forecast to increase by seven percent per annum over the same time period.

The emphasis here is on the effort to achieve modal shift from the private sector to the public sector via infrastructure improvement or at the very least to reduce the trend of movement away from the public sector. The model structure under discussion in this paper is the mode split segment of the overall Abidjan transport model. Other methods of modal shift for Abidjan other than improvement in the city modal structure may include the introduction of area pricing [8]. Other such alternatives are possible for evaluation within the transport model structure.

##### 3.2.1 Model Structure

The nested logit model[9] is often used in mode city analysis for both city wide transport and even in the case of long distance transport[10]. The model structure with four levels of mode split analysis including the walk mode is depicted in Fig 7. Each model level has its own logit mode split curve.

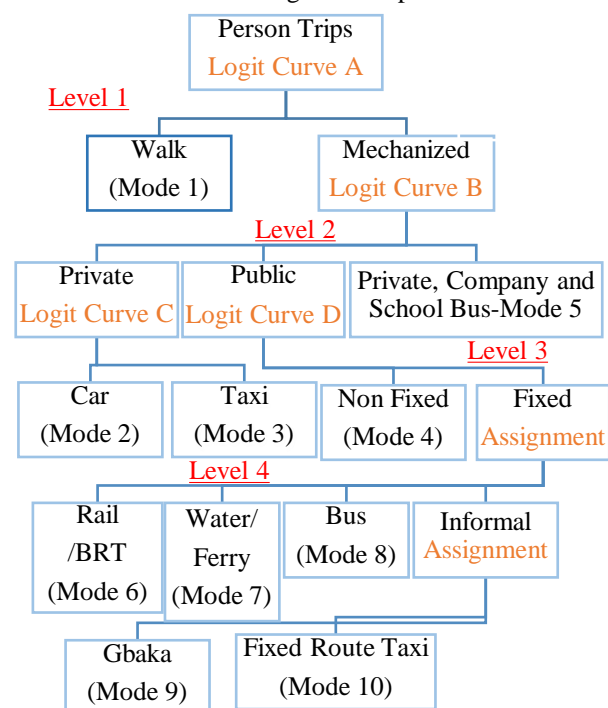


Fig. 7 Mode split structure.

The first curve separates the mechanized trips from the walk trips whilst at the next level, there is a choice between the public and private modes including special school buses. On the private side, there is a distinction between the private car and motorcycle. On the public side, there is a distinction between the non-fixed route and fixed route transit modes whilst the final level of fixed route transit includes modal allocation within the phase of the public transit assignment.

### 3.2.2 The Equations

The modal shift equation takes the following form:

$$1/(1+\exp(-\lambda(C_{ij}^2+\delta-C_{ij}^1))) \quad (1)$$

Equation (1) defines the probability of using mode 1 as opposed to mode 2 whereas  $\lambda$  is the scale parameter and  $\delta$  is the bias as defined in Table 3;  $C_{ij}^1$  is the generalized cost of travel for hierarchical mode choice 1 between any two traffic analysis zones i and j; and  $C_{ij}^2$  is the generalized cost of travel for hierarchical mode choice 2 between any two traffic analysis zones i and j.

The generalized cost is a function of travel cost and travel time. For public transport, the cost is the total fare including any access fare to the main transport mode. Travel time is the total time from the start of the trip to the end of the trip.

The mode split parameters for only the work trips representing twenty percent of all trips in Abidjan are depicted in Table 3. All four logit curves, A through to D are described for the four levels of economic activity level in Abidjan. In the model development, both trip generation and trip distribution were also prepared for three additional trip purposes namely school, shopping, and non-home trips.

Table 3 Mode split parameters for work trips

Economic Activity Class	Curve A (Mode 1=walk)			Curve B (Mode 2=private)		
	$\lambda$	$\delta$	$R^2$	$\lambda$	$\delta$	$R^2$
Class 1	0.46	3.9	0.60	0.01	-32.6	0.62
Class 2	0.35	4.4	0.60	0.01	-15.7	0.63
Class 3	0.44	2.7	0.60	0.01	72.6	0.60
Class 4	0.22	1.9	0.63	0.01	-49.0	0.64
	Curve C (Mode 3=car)			Curve D (Mode 4=non fixed)		
	$\lambda$	$\delta$	$R^2$	$\lambda$	$\delta$	$R^2$
Class 1	.005	-478	0.63	0.005	-234	0.59
Class 2	.019	200	0.85	0.005	-48	0.58
Class 3	.005	152	0.61	0.005	184	0.58
Class 4	-.01	183	0.57	0.005	-252	0.99

Each curve as referenced in Table 4 is prepared

four levels of economic activity. The levels of economic activity are directly related to the different levels of household income. The measure of goodness of fit, in this case, is in the form of the  $R^2$  value which is considered within acceptable ranges for this form of model calibration.

### 3.2.3 Model Calibration

Before a model is usable, it must reproduce the existing situation. If it can reproduce the existing situation within reasonable limitations, it is thus deemed a calibrated model.

In the case of the Abidjan modal split model, as seen in Table 4, there is a close estimation of both the mode split at the macro level for public transport and the three individual sub- modal levels. The maximum difference even at the sub-modal level is only seven percent.

Table 4 Calibration Comparison

Mode	Percentage Difference
Walk	0.3
Private	-4.8
All Public	6.3
Bus	4.8
Gbaka	2.2
Woro-Woro	7.2

In addition, in the calibration phase, it is common to compare traffic movement across a screenline. Four such screenlines reflected a good match between observed and estimated traffic. The comparison was within ten percent which is considered a reasonable comparison.

## 4. THE ANALYSIS

The focus of this research is on the modal shift or in overall terms the maintenance of the modal balance by the reversal of the decline in public transport share. However, prior to the modal allocation step, there is as previously discussed the trip generation and distribution of the movement of people. Person movements are estimated by traffic zone via a relationship linking population and economic activity.

The cost and time of travel are the key inputs into the mode split model, Eq. (1). The travel time includes all portions of the public transport travel thus incorporating travel by the main mode in addition to access, waiting time, transfer time and any modal boarding penalties.

The movement pattern that meets the objective of improvement in transport within Abidjan is the incorporation of corridor movements and a local ladder pattern providing residential access from the

main corridor movements. This combination forms an integrated pattern as depicted in Fig 8. is then the input for analysis within the structure of the transport model.

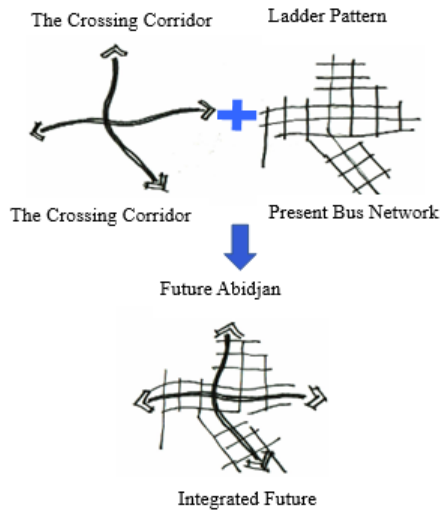


Fig. 8 Future public transport integration.

The decline in public transport is halted in the future as reported in Table 5 resulting from an integrated approach to public transport. In terms of physical infrastructure, this is achieved in the additional investment in public transport of the East-West transit corridor linking the communes of Yopougon and the Plateau and the North-South corridor linking the communes of Abobo and Port Bouet as depicted in the earlier Fig. 5.

Table 5 Modal shift

Mode	2015	2030
Walk	39.8	34.8
Private	10.1	13.8
Public	50.1	51.4

The informal sector is also reduced in the future with the forecasted estimated modal share of Woroworo by nearly thirty percent. This is a result of a better environment and improved transit efficiency.

## 5. RESULTS AND CONCLUSIONS

The trigger for the upgrading of public transport services in Abidjan is the introduction of the high capacity transit corridors namely the introduction of Bus Rapid Transit (BRT) as depicted in Fig. 9 and a Bus Higher Level of Service (BHLS). Without these services, there will be little incentive for public transport improvement. The purchase of additional SOTRA buses will improve the status of SOTRA.

This purchase will enable additional services on

their existing line haul routes in the short term. Whilst at later stages of the public transport timeline when buses are released from this role as the high capacity transit corridors come on line, SOTRA will then have the ability to use buses to access these high capacity transit corridors. SOTRA will provide new services to access as well as outlying centers not served by BRT or BHLS.

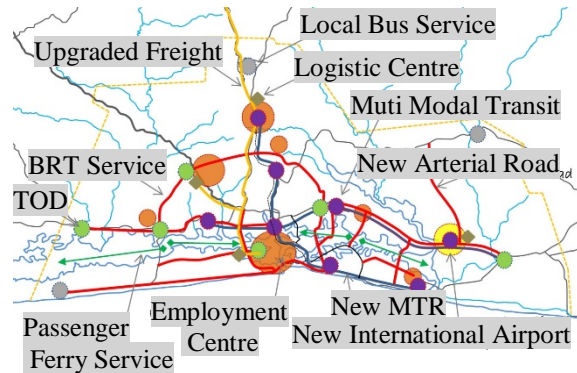


Fig. 9 Future public transport structure.

A new proposed regulatory authority will not only be responsible for the standard of operational service and ensure service. It must also have a role in the insurance of the safety and maintenance of public transport in Abidjan. The future will demand a high level of training of staff of the new services in Abidjan. It is thus recommended that the new operators and relevant agencies provide a high level of in-house training.

Additional infrastructure in conjunction with an updated regulatory framework will move Abidjan towards the maintenance of the public transport mode.

### 5.1 Feasibility Of Green Modal Shift

There is an anticipation of halting the decline in public transport in the future as a result of the introduction of a more efficient and environmentally friendly or greener form of transport for Abidjan. The movement towards an efficient and greener transport system is also in accordance with supporting the Paris climate accords.

## 6. ACKNOWLEDGEMENTS

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All ideas and views expressed in this paper are those of the authors. They do not necessarily reflect any of the sponsoring authorities of projects discussed in this paper or any organizations

associated with the respective authors.

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