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Attaining Millenium Development Goals (Mdg) Through Bus Rapid Transit (Brt) System (A Case of Brt Ticketing System in Lagos State, Nigeria)

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Abstract - Transportation in Lagos State, Nigeria is a major challenge that over the years had called for serious attention. Every attempt at solution seems to compound it. We conducted a review of the literature in the area of BRT systems to identify and subsequently classify their major aspects, and determine their linkages and trade-offs. Also, we developed from a theoretical point of view the basis of the BRT deployment planning framework, followed by collecting the necessary data to exercise the framework in the context of a site-specific case study (Lagos State). We adopted a system optimization approach in order to assist transit agency to decide on optimal deployment strategy to employ. The study reveals that the deployment of BRT systems relative to an array of factors ranging from large, small and site-specific cases among other things do not only ameliorate the challenge of transportation but also in a way attempted to do justice to the first MDG agenda of attainment of low-pollution Green House Gases (GHG). Also, reveals that ticketing system needs a radical approach to curb time-loss occasioned by validation of purchased tickets.

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ATTAINING MILLENIUM DEVELOPMENT GOALS MDG THROUGH BUS RAPID TRANSIT BRT SYSTEM A CASE OF BRT TICKETING SYSTEM IN LAGOS STATE, NIGERIA

Strictly as per the compliance and regulations of:

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I. Introduction

According to Miller et al (2004), in U.S.A the transit industry nationwide has developed significant interest in BRT as currently there are in excess of 200 transit agencies that at least considering BRT alternatives and a few dozen properties are conducting planning exercises, utilizing planning methods such as Major Investment Studies (MIS). Fares should be integrated with the rest of the bus system, but they may not necessarily be the same. Miller & Buckley (2001) asserted that running ways for BRT include mixed traffic lanes, curbside bus lanes, and median bus ways on city streets; reserved lanes on freeways; and bus-only roadways, tunnels, and bridges. Most stations are located curbside or on the outside of bus-only roadways and arterial median busways. Similarly, BRT stations have low platforms since many are already or will eventually be served by low - floor buses. Conventional standard and articulated diesel buses are in wide use for BRT operations, though, there is a trend toward innovations in vehicle design, including environmentally clean or green vehicles, such as diesel-electric vehicles and compressed natural gas-fueled vehicles, dual mode operations in particular environments such as tunnels, low-floor buses, additional as well as wider doors, and use of distinctive and dedicated bus rapid transit vehicles. Service innovations include fare collection procedures, station design and location, and more attractive vehicle designs. Intelligent transportation systems range from existing and more customary automatic vehicle locations systems, transit signal priority systems, and passenger information systems to more advanced systems including collision warning systems (frontal, side, and rear), and automation technologies including lane assist systems — precision docking and automatic steering systems — and automatic speed and spacing control systems.

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II. Materials and Method

Source: World Bank Transport Forum: March 30th – April 1st 2009, "Transport: Invisible Force – Visible Impacts" - A Presentation By Babatunde Raji Fashola (SAN) Executive Governor, Lagos State, Nigeria

BRT elements should be included in the system from the seven elements of any BRT systems namely Exclusivity of Running Way, Advanced Bus Technologies, Improved Fleet Management Technology, Distinctive Aesthetics or Amenities, Faster Fare Collection and Boarding, Integrating Transit Development with Land-Use Policy and Innovative Project Delivery Methods. Subject to budgetary, institutional and other constraints associated with the corridor, transit agencies have to cost-effectively configure their BRT systems, which must be tailored to site-specific characteristics. To achieve this goal, we adopted systems optimization approach with adequate and realistic objectives and constraints. A planning framework, reflecting this approach, was used to assist transit agencies with this task.

a) The Physical Environment

The physical presence of a BRT system may also raise institutional challenges. Many project areas, especially in older city centres, may simply lack the physical space to easily accommodate certain BRT implementation strategies. Bus rapid transit projects may also find themselves competing with other interests for high value real estate, which may not only inflate costs, but also complicate institutional dealings. Thus, availability and acquisition of right-of-way or physical space may be an issue. Image is also a strong marketing tool for BRT. While station area improvements are a popular BRT strategy, these improvements are typically being inserted into the existing urban design. Deng & Nelson (2010) in their findings that a high-quality BRT systen can offer accessibility advantage (specifically travel time saving) to adjacent properties, and thus increase their attractiveness. Interviews with stakeholders, including government officials, developers and real estate agents, and longitudinal analysis reveals that BRT line has positive development effects on adjacent properties, reflected by higher property values and accelerated development. The results further suggests that the housing near BRT stations enjoy a value premium, and develoment has been stimulated by the BRT opening. The findings also provide evidence that accessibility enhancement, rather than the type of transit system, is a far more important reason to influence land development. Organizations may find it a challenge to reach agreement or consensus to develop station improvements that promote a strong image, while being acceptable to numerous local interests.

In the domain of environmental management or policy, it is probably safe to say that most developers of eco-informatics tools or information *hope* that their work will be utilized in some form of rational decision-making processes or that at the very least, their tools and information are used to help inform incremental decision-making processes. For example, Tonn, et al. (2000) provide a framework to guide environmental decision-making in which goals and values are agreed upon, planning is pursued, and then decisions are developed and implemented.

The proposed deployment-planning framework is depicted in Figure 1.2-1,

The activities and corresponding methodology for each step are described below.

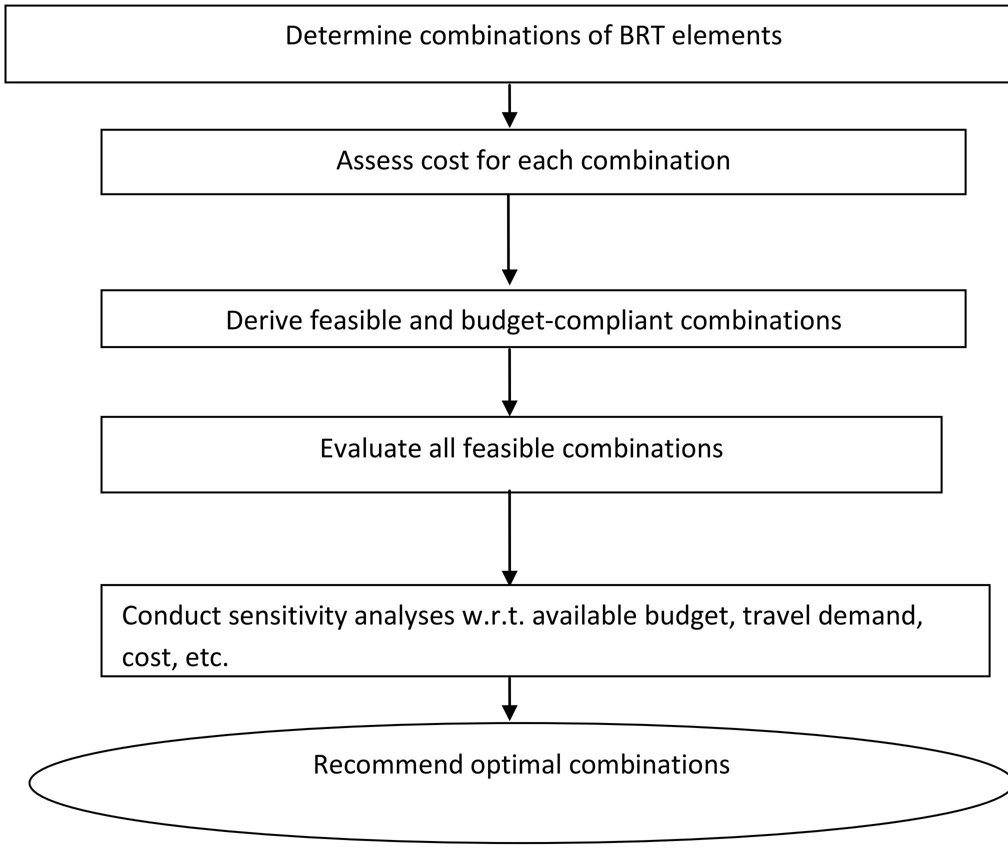

Figure 1.2-1 : A Framework for BRT Deployment Planning.

There are several combination of BRT elements, this of course tells on the need for each cost. For this purpose, it must be borne in mind that costs of BRT elements may vary based on the specific technology being used, integrated deployment of BRT elements may save significantly and that operating and maintenance cost must be considered. We focused on four aggregate performance measures and objective functions that may be used by agencies seeking to improve overall level of service. The objective functions are relatively easy to quantify and represent the combined views of passengers, the operator/transit agency and the community, which are the three primary stakeholders. However, these objective functions are only concerned with cost-efficiency of BRT-element combinations for an existing (known) passenger demand. In order to evaluate the cost-effectiveness, changes in ridership with respect to the implementation of selected BRT elements should be forecasted. This can be achieved either by a "learning curve" of an existing similar BRT system in operations, or via market research including potential system customers and non-users.

b) ABMS and Traditional M&S Techniques

According to Oyatoye & Magbagbeola (2010), Agent-based modelling system (ABMS) can provide an overarching framework for model based on other modelling techniques. For example, models may be composed of agents whose decision-making behaviors are represented by formal optimization problems or by informal heuristics decision. According to Tonn et al (2000), heuristic decision, mean strategies that help produce correct solution. Heuristics don't always produce a correct answer, sometimes they are the reason why people make wrong decisions. Another example is agent behaviors represented as statistical models deriving agent behaviors from the agents' input information. Agent-based modelling can also be used as a complement to other modeling techniques: for example, an agent model that builds system behavior from the behaviors of the individual agents can be "docked" (used in conjunction) with a more aggregate Systems Dynamics model of the system, to see whether the two approaches yield similar results over a range of test cases. The goal of this study is to model a many-to-many demand responsive transit service without predefined itineraries and schedules. In this case, the fleet has to be dispatched exclusively on the basis of the list of requests, like in taxicab systems, the difference being the possibility of serving customers with some detours in order to share the ride. We believe that this kind of service is of particular interest for the possibility of offering a high quality service with an efficient allocation of the resources. To achieve this, we have modelled a service in which time windows are associated with each pickup and delivery point. The definition of time window is different from the notion of "time deadline" that can be found in previous works, for example concerning hauling services Hall (1996). Although Daganzo (1987) modelled a distribution problem considering time windows associated with each delivery point, the suggested methodology is not suitable when temporal constraints are tight as in the case we are considering. Thus, we need a procedure that is not easily derivable from existing methodologies. For example, comparing our problem to the previously discussed ones, it can be observed that in our case, it is impossible to model it as a fixed-line service since we cannot define a "path" or a "headway" between the vehicles. On the other hand, the joint need of avoiding transfers for any pair of pickup and delivery points and of limiting the maximum ride time for every customer prevents us from dividing the area into several service zones served by a single vehicle, hence, a "cluster-first, route-second" model is not appropriate.

This work may not include all the detailed procedures of deficit function theory and will

concentrate rather on estimating the minimum fleet size required for a fixed schedule

(shifting of departure times is not allowed), which will bring to focus the identified challenge of time-loss during ticketing and validation to departure time of any trip in our case study (Lagos state).

III. Result and Discussion

Source: Field Survey (2011) - Queuing for BRT in Lagos State.

c) *Modified Stopping–time Delay Model (MSDM)*

Interestingly, according to Zhuo et al (2009) formula for basic model i.e. *Stopping-time Delay Model* (SDM) under the background of BRT system to realize "bus priority" by setting passing order of traffic streams at a cross. This was intended to allow for buses to go through the cross much quickly than before, and congestion is avoided. In our case study, the delay as expressed has other components as the ticketing is still manually handled. The validation of the tickets is left to the checkers attached to the drivers of the BRT. This alone is envisiaged to be bedeviled by several ills ranging from the use of fake tickets to continuous delay in checking same and other attending vices. Our work shows this disconnect and we thus proposed the use of our Modified Stopping-time Delay Model (MSD model) based on the work of Zhuo et al (2009). To prevent the bus delay caused by the initial congestion of getting on and off at bus station and its additional time-loss through ticket checking as validation, we builld a model about the number of passengers getting on and off to control the stopping time. Our newly introduced variable t_{wt} (Time occassioned by ticket checking and validation) to the adapted model explains in clear term the otherwise laten time-loss unaccounted for in our case study. Our study reveals attempt at addressing this abnormallity through deployment of relevant and timely model deployment and necessary suggestion(s) to ammeliorate this lacuna occassioned by the choice of partial deployment of the BRT system in Lagos state.

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Variable	Meaning
t_{st}	Time at bus stop
t_w	Waiting time (waiting for last bus leaving bus stop)
t_p	Time for passengers getting on and off
t_c	Minimum time from bus leaving station to next bus stopping at station
t_{wt}	*Time occassioned by ticket checking and validation*
N_{on}	Number of people getting on
N_{off}	Number of people getting off
K	Number of buses before this bus come into station
t_{pe}	Average time needed to get on (off), which is a constant
t_{oc}	Average time for each bus to close doors, which is a constant

$$\text{So } t_{st} = t_w + t_{wt} + t_p + t_{oc} + t_c \tag{1}$$

Let N=max (N_{on}, N_{off}) Then

$$t_p = N \cdot t_{pe} \tag{2}$$

t_w is equal to the sum of t_{wt}, t_p , t_{oc}, t_c of early buses

$t_w = (t'_{p1} + t'_{p2} + ... + t'_{pn}) + k \cdot t_{oc} + (k-1) \cdot t_c + (k-2) \cdot t_{wt}$

(n is the number of buses)

$$t_w = (N'_1 + N'_2 + ... + N'_n) \cdot t_{pe} + k \cdot t_{oc} + (k-1) \cdot t_c + (k\ 2) \cdot t_{wt} \tag{3}$$

$t_{st} = t_w + t_{wt} + t_p + t_{oc} + t_c = (N'_1 + N'_2 + ... + N'_n) \cdot t_{pe} + k \cdot t_{oc} + (k-1) \cdot t_c + (k-2) \cdot t_{wt} + N \cdot t_{pe} + + t_{oc} + t_c$

In peak hours, $N \equiv N_{on}$

$$N_{be} - N_{af} + N_{in} = N'_1 + N'_2 + ... + N'_n + N \tag{4}$$

(N_{be} is the number of people at this station when this bus is there, N_{af} is the number of people at the station after this bus leave this station, N_{in} is the number of people entering the station during this period). We collected some data,

Table 1 : Observed Data.

Symbol	N_{be}	N_{off}	N_{in}	t_{pe}	k	t_{oc}	t_c	t_{wt}
Value	100	55	15	2	2	3.6	4	**4**

Field Survey 2011

We have $t_{st} = t_w + t_{wt} + t_p + t_{oc} + t_c = (N_{be} - N_{af} + N_{in}) \cdot t_{pe} + (k+2) \cdot t_{wt} + (k+1) \cdot t_{oc} + k \cdot t_c = (100 - 55 + 15) \cdot (2) + (2+2) \cdot (4) + (2+1) \cdot (3.6) + 2 \cdot (4) = 164.8\text{s}$

Data presented in line with real situation as obtainable in our case study (Lagos state), but based on successful experience of foreign countries, the average stopping time of BRT system is 40 seconds according to Jun & Kangming (2007). So for the existing public transport system, the stopping time is far too long, it will amount to inefficiency of this system.

By using

$t_{st} = t_w + t_{wt} + t_p + t_{oc} + t_c$

then $(t_{st1} + t_{st2} + ... + t_{stm})/m \leq 40$ seconds

(m is the number of stations for a route)

Hence, we plugged in the related data to calculate stopping time and control the number of passengers, and hence make the buses run more quickly and conveniently.

c) *Institutional and Policy Issues*

This section has thus far focused on the more technical, design, and operational aspects of bus rapid transit systems, ranging from system requirements, available technologies and practices, system architecture, and simulation tools for system testing to evaluation. Miller (2001) and Miller & Buckley (2001) stated that the implementation of bus rapid transit systems traverses numerous stages of system design, development, testing (simulation and field), evaluation, and deployment culminating in a completed and fully operational system. Moreover, all these activities take place in a context with organizational stakeholders participating at various levels. As each stage of BRT implementation proceeds through its more technological, design, and operational aspects, questions may arise concerning the impacts of actions to be taken or decisions to be made. These impacts are often of a non-technical nature and are referred to as institutional issues. Such less technical or operational questions and issues resulting from them need to be

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considered and addressed as well to successfully implement a bus rapid transit system.

IV. Conclusion and Recommendation

Fare collection system should facilitate multiple door boarding, at least at major stops during busy periods. Off-board collection (preferred) or on-board multipoint payment should be encouraged to alleviate the challenge occasioned by poor ticketing option currently adopted in our case study. Even the recently proposed newly introduced e-ticketing payment system into the public BRT, which is supposed to put end to the current use of paper payment system will not help to put to abeyance this challenge of time-loss occasioned by validation of tickets. Marketing should emphasize the unique features of BRT such as speed, reliability, service frequency and span, and comfort. We therefore recommend that the adopted deployment which is partial in nature should be revisited with a view to revisit the ticketing regime. We hereby recommend as a way out of the time-loss challenge the need for deployment and full implementation of e-ticketing that allows for the tickets to be obtained without stress to the commuters and also reduce drastically the queue generated by this exercise and the need for checking officers on board to carry out their traditional role of inspection of the tickets to ascertain if valid for the trip or not.

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