STUDY ON AN OPTIMAL SYSTEM DESIGN FOR BUS RAPID TRANSIT IN VIENTIANE, LAO PDR*

by Phanthaphap PHOUNSAVATH**, Xuepeng QIAN*** and Mamoru HARUNA***

1. Introduction

Vientiane is a small city with approximately 731,000 residents (estimated in 2007). However, traffic congestion has already become one of serious problems. This is due to the increasing of private vehicle usage such as passenger cars and two-wheel vehicles for 25% per year. Accident on the roads is also increasing, which most of the cases involved with 2-wheel vehicle and passenger cars. The above-mentioned problems can possibly be solved if the bus service is improved providing efficiency and effectiveness. In this study, Bus Rapid Transit (BRT) is introduced in order to serve as an alternative mode on the existing road infrastructure between Urban districts and Centre Business District with its special characteristic of high quality bus-based transit system that provide fast, comfortable and cost effectiveness within urban mobility.[1] This research therefore attempts to study an optimal design of BRT system. The study route was selected based on the appropriate road infrastructure and also where there are large communities and high demand of travel between Thong Pong via CBD and the National University for the total length of 23 km (figure 1).

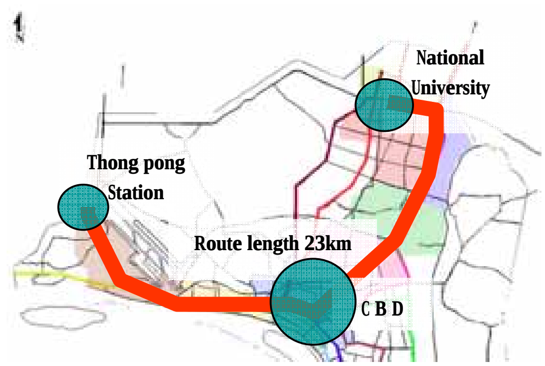

Figure 1 Map of Study Area (Northern part of Vientiane City)

2. Modeling and Analysis of BRT System

BRT system varies in specific characteristics, but all provide a higher level of service than traditional bus transportation. The service can be achieved in multiple ways, including bus operation on separate lane, limited stops, prepaid fare system, signal prioritization, and real-time information for passengers waiting at station. A final key feature of BRT systems is the high level of integration with existing and future land use patterns.[2]

(1) Modeling of BRT system

Since operating BRT system provides lots of benefits, a BRT Project framework was therefore set out the system planning and be implemented by particular sector of government in year 2010 and to be evaluated in year 2020 as suggested in the National Plan. There is enough evidence to suggest that BRT provides several ways in which a transport improvement might affect productivity. One is that the system provides economic saving for riders, social cost such risk of having accident and environmental cost also can be reduced. In addition, improving accessibility within the city the effective density of the cluster rises and another is that overall city employment is increased. With all the result,

*Key Words: Bus Rapid Transit, cost-benefit analysis, Optimal System Design
**Student Member of JSCE, Master Student of Ritsumeikan University, Urban and Regional Planning Laboratory, Nojihigashi, Kusatsu, Shiga, 525-8577, Tel: +81-77-561-2667
***Member of JSCE, Dr. Eng., Ritsumeikan University, Urban and Regional Planning Laboratory, Nojihigashi, Kusatsu, Shiga, 525-8577, Tel: +81-77-561-2667

benefits gained from economic saving and more income generating was given to users. With the increase of riders, it also generates more revenue and tax return to local government (Figure 2).

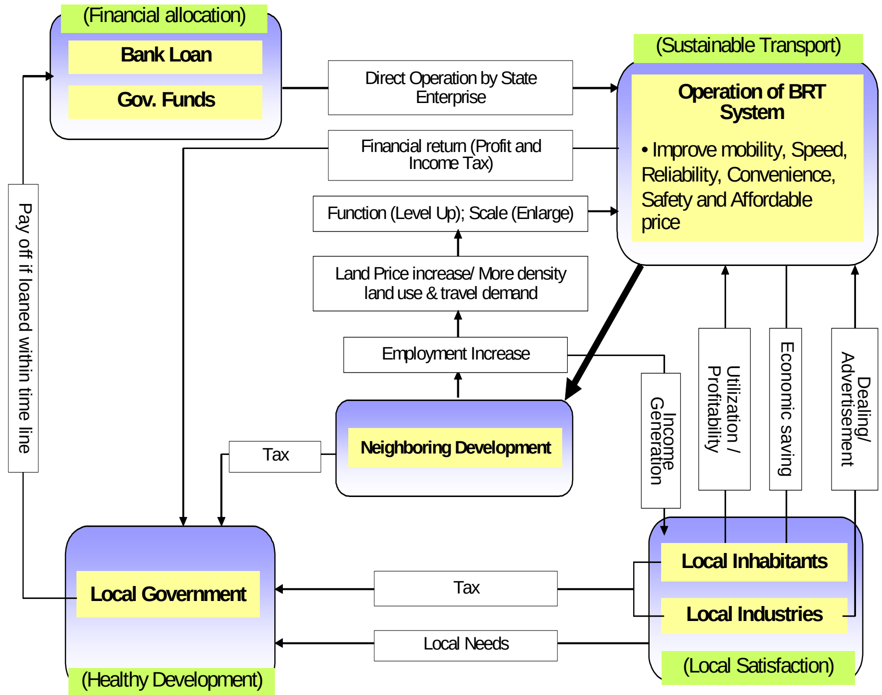

Figure 2 Framework for BRT Project Planning

The flow of this study conducted in 3 major steps: First, passengers forecasting for BRT system based on the obtained stated preferences and information from survey and then conducted traditional travel demands modeling. Second was analysis of Costs: capital, operating and maintenance cost. And benefits: travel time cost saved for current bus riders, reduced cost for new BRT riders, reduced pollution cost, and reduced accident cost, which estimated based on Sensitivity Analysis.

The criteria of element combinations and selection (Table 1), was base on the result from considering improvement of existing level of service and reduce costs, technical feasibility, institutional constraints, and the use of elements that provide travel time reduction and increase features to encourage more riders, then access all cost and benefit for each combination with respect to travel demand, and finally select optimal system for BRT. Finally, the last step will be financial simulation for the BRT Project Determining combinations of BRT. This cost-benefit analysis uses a net present value model to compare the hypothetical implementation of five element combinations. To do this, we quantified for all relevant cost and benefit categories, monetize these changes, and then sum the costs and benefits over the life of the project.

Table 1 Sets of Combinations for BRT system

Combination \ Elements	Exclusive Median Lane	Stop / station	Fare Vending Machine	Signal Control System	Real time Info.
Basic-Improved	Applied	Applied			
Semi-Moderate	Applied	Applied	Applied		
Moderate	Applied	Applied		Applied	
Enhanced	Applied	Applied	Applied	Applied	
High-Enhanced	Applied	Applied	Applied	Applied	Applied

(2) Analysis of BRT system

The analysis relies on principal assumptions found in the transportation CBA literature. First, the cost of travel involves direct marginal monetary costs, such as transit fares, fuel costs, tire deterioration and the cost of an individual's time spending. Second, People choose their travel mode based on the total cost of travel, which includes direct monetary plus time costs. And third, some social costs are not reflected in the private cost of travel. By reducing these externalities, social benefits can be gained.[3] Implementing a BRT system would have the potential to affect several travel modes. In this study, the reveal of stated preference helped to make up the choice model of each group based on traditional 4-step modeling method. The choice set includes private car, motorbike, conventional bus and BRT. Three mode shifts are expected: the shift from private cars and motorcycles to BRT and the shift from conventional bus to BRT. In addition to persons who walk, bicycle could experience changes in cost and benefits due to the implementation of BRT. However, because of limited data available and assumption that people traveling by modes other than bus or automobile would experience negligible changes in net benefits. Therefore, we only analyzed the impact of BRT system on two transportation mode: bus and automobile.

In the aspect of Cost Benefit analysis, estimating transit and vehicle trips, along with their expected length and travel time, is critical to determine the magnitude of benefits that arise from the BRT combinations evaluated in this cost-benefit analysis. For sensitivity analysis, costs and benefits are estimated based on the functions stated in (Table 2). In order to measure Travel time cost reduction, the gross average hourly wage rate for Vientiane city workers is used. The rate is 3,700 kip/hour (1US$=9,000 kip).[4] The second benefit was Vehicle user cost reduction. Vehicle miles travels were expected to decrease with improvements of the bus system. Marginal cost in this analysis include fuel, oil, tire deterioration, vehicle depreciation, and maintenance are estimated with the best possible assumption. The third benefit is Reduced Vehicle Air Pollution Costs. This analysis estimates the social costs as including damage, and restrictions created on outdoor activities. The decreased cost of air pollution is a benefit derived from having a bus system that attracts more riders and therefore, decreases the vehicle miles traveled each day. Change in annual vehicle travel refers to the difference between each BRT combination. The reduction in vehicle air pollution costs is a benefit for five combinations and is included in the calculation of net benefits for each combination. The last benefit estimated in this study was accident cost reductions. Accident placed significant cost in society. The average annual number of accidents is positively related to vehicle travel. Accordingly, the social cost of accidents decreases when fewer vehicle miles are traveled (Table 3).

$$Z_1 = C_{cp} + C_{op} + C_{mn} \quad (1)$$

$$Z_2 = \delta_{ts} + \delta_{cr} + \delta_{ar} + \delta_{pr} \quad (2)$$

Table 2 Cost-Benefit Variables

Variables		Variables	
Total Cost	Z_1	Time cost saving for existing bus rider	δ_{ts}
Total Benefit	Z_2	Cost saving for new transit riders	δ_{cr}
Capital cost	C_{cp}	Reduced air emission cost	δ_{pr}
Operations ; Maintenance cost	C_{op} ; C_{mn}	Reduced accident cost	δ_{ar}

Table 3 Cost-Benefit Parameter Equations

Cost Categories	Equations
Reduction of Travel Time Cost	*Time traveled by conventional bus minus Time traveled by BRT *no. BRT users*
Marginal Vehicle Cost	*Annual VMT * Marginal Cost of VMT*
Reduction in Vehicle Air Pollution Cost	*Change in Annual VMT * Air Pollution Cost per VMT*
Total Air Pollution Cost	*Additional Annual BTM * Cost of Air Pollution per BMT*
Accident Rate Per VMT Travel	*Average Annual Accidents divided by Vehicle Miles Traveled*
Average Cost Per Accident	*Average Annual Cost for Accidents divided by Average Annual Number of Accidents*
Annual Accident Cost	*Annual VMT * Accident Cost per VMT*

3. Findings and Propose Based on Analysis

To arrive at the estimate of the net present value of each combination, the following benefit categories were considered: (1) reduced travel time for current bus users, (2) reduced vehicle user cost for new users, (3) reduced air emissions and (4) reduced accident costs. Analyzed cost categories include: (1) the capital costs of building BRT system, and (2) operations and maintenance costs of a BRT system. Based on the result of analysis (Table 4), all five combinations in this study demonstrated that implementation of a Bus Rapid Transit System in Vientiane would have high positive net value. In this study, optimization of the system is critical and focused. In order to obtain maximum benefit with minimum investment, Alternative of System Enhanced is selected as the result shown was to highest net benefit for the total of US$44.73 over the projected year (Figure 3). However, another way in interpreting the result, it is important to keep in mind the potential benefits that could be derived from (1) alleviating congestion, (2) providing individuals with the option of using a higher quality bus system, (3) increasing low-income mobility, and (4) economic development and growth. If the monetization of this benefit is beyond the scope of this project, it is therefore possible that the system of High Enhanced could be selected as a second consideration as its net benefit value figure shown was only a little lower and costs were not so much higher than the optimal one.

Table 4 Net Present Value of Project Benefits (mill. US$)

Cost and Benefit Categories	Basic Improved	Semi-Moderate	Moderate	Enhanced	High-Enhanced
Capital Cost	$7.09	$7.15	$6.34	$6.84	$7.66
Operations and Maintenance	$1.42	$1.37	$1.57	$1.55	$1.91
Subtotal	*$8.51*	*$8.52*	*$7.91*	*$8.39*	*$9.57*
Time Saving for Current Transit Riders	$2.90	$4.59	$5.68	$7.23	$7.25
Reduced Costs for New Transit Riders	$17.16	$17.88	$18.25	$19.08	$19.18
Reduced Vehicle Air Pollution Cost	$0.32	$0.32	$0.33	$0.34	$0.34
Reduced Accident Costs	$23.17	$24.20	$24.94	$26.12	$26.26
Subtotal	*$43.55*	*$47.00*	*$49.19*	*$52.76*	*$53.03*
Total Net Present Value	***$35.04***	***$38.48***	***$41.28***	***$44.37***	***$43.46***

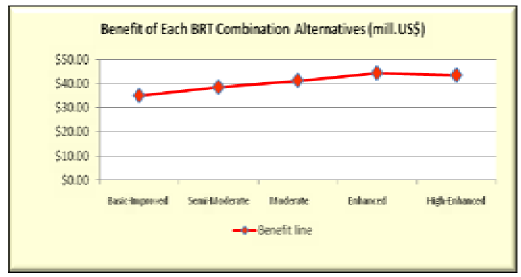

Figure 3 Net benefit of BRT combination

In the aspect of policies, our society provided too much convenience for private transportation use, and it has caused the cost of private transportation users to pay are lower than they have paid. In addition, more social cost, congestion, air pollution cost were increased. In order to solve these problems, we can establish reasonable tax and fee policies, e.g. air pollution tax, congestion fee and some tolls. We can also limit the convenience of road user, e.g. limiting private transportation users to enter some regions and decrease private transportation road use space.

4. Conclusion

This study was made as a feasibility study to find out cost-benefit of each alternative and to arrive with the optimal element and feature design of BRT system. It could be used as a systematic methodology for macroscopic project planning in the future. However, due to many assumptions were made and data limitation, this prevented us from monetizing some actual potential cost and benefit categories. In addition, cost-benefit analysis only looks at economic efficiency. Other important policy goals such as public transport prioritization, equity and sustainability should be considered when evaluating transit investment. For further study, financial simulation for BRT Project will be estimated to ensure the feasibility of the new project and policies for Environmentally Sustainable Transport will also be included.

Reference:

1. Wright, L.: *Bus Rapid Transit Planning Guide*, 2007
2. Blonn and Carlson,: *Transport 2020 Bus Rapid Transit: A cost Benefit Analysis*, 2006
3. Banister and Berechman,: *Transport investment and economic development*, 2003
4. Ministry of Planning and Investment,: *Social Economic Development Report & Vision Toward 2020*, 2004