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Study on Transit Short-Range Planning of Urban Public in Vientiane Capital (Laos)

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Vientiane is a main of transportation of the country and a corridor for freight and passenger transportation. Current urban public transportation system has not been updated; due to lack of technology and financial resource to support for operating service and maintenance. As a result, due to lack of an urban public transport service in an area (for students, employment etc); urban traffic has been cumulatively influencing urban socio-economic and urban environment. Currently, urban population and industries have been growing rapidly; in terms of urban public transportation could not able to service enough an urban traveling demand. Therefore, the urban public transportation planning and management is needed of improvement. In order to solve urban traffic problems in a short terms and long terms is to encourage regional economic development. Transit short-range planning of Urban Public has introduced a city bus transit system incorporating eight lines in six districts of Vientiane. The first, traffic simulation models have been constructed to calculate the trip generation and transit passengers. The second, optimal design of bus transit includes models using the transit standard equations for analysis. The third, cost-effectiveness equation was used to estimate the bus transit service operation costs and cost savings on new transit riders. The final analysis, the External Interest Rate of Return, was calculated in order to assess the feasibility of operation over the planed years of service.

Keywords: Urban transportation planning, bus transit planning and optimal design

1. Introduction

Vientiane is the Capital city of Lao People's Democratic Republic. It is situated along the east bank of the Mekong River. The area of Vientiane is about 3,920 square kilometers including nine districts. Urban population is approximately 698,000 in 2005 and population densities range from 149 to 2,200 persons per square kilometers which is the highest residential density of the country. As the current urban public transportation service has not been up to date due to lack of technology, technical and financial resources. In the other hand, urban population has been increasing rapidly in recent years at the average rate of 2.1% annum and traffic growth rate is 22 % per annum; urban traffic has been cumulatively influencing urban socio-economic and urban environment of the region.

Therefore, this study aims to conclude the proper methodologies and the appropriate models in order to apply optimal design of city bus public transit as a system effectively and efficiently. The result is expected to support and foster the development of densely developed areas and employment especially in central area. It provides mobility for the elderly, handicapped and other who are unable to drive.

The planning areas cover six districts, total area 1,521 kilometers square, with 576,352 habitants, residential density of 1,384 persons per km^2, and the plan of city bus transit includes 8 lines in 6 districts with the total length of 103 km. The bus transit is planned on arterial road with daily traffic more than 40,000 vehicles per day.

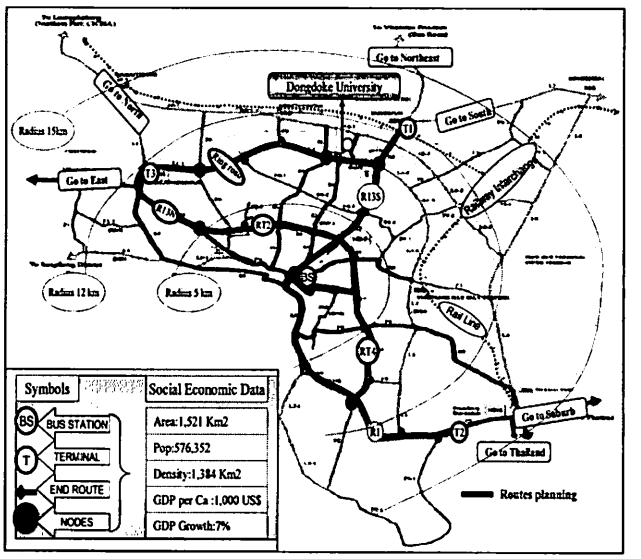

Figure 1: Map of Study Area

2. Functional Design of Bus Transit System

Public transit studies have defined in a large scale to provided public services covering all public transportation of people; while the study has assessed the quality of transit being provided in a planning area and making planning for service improvements.

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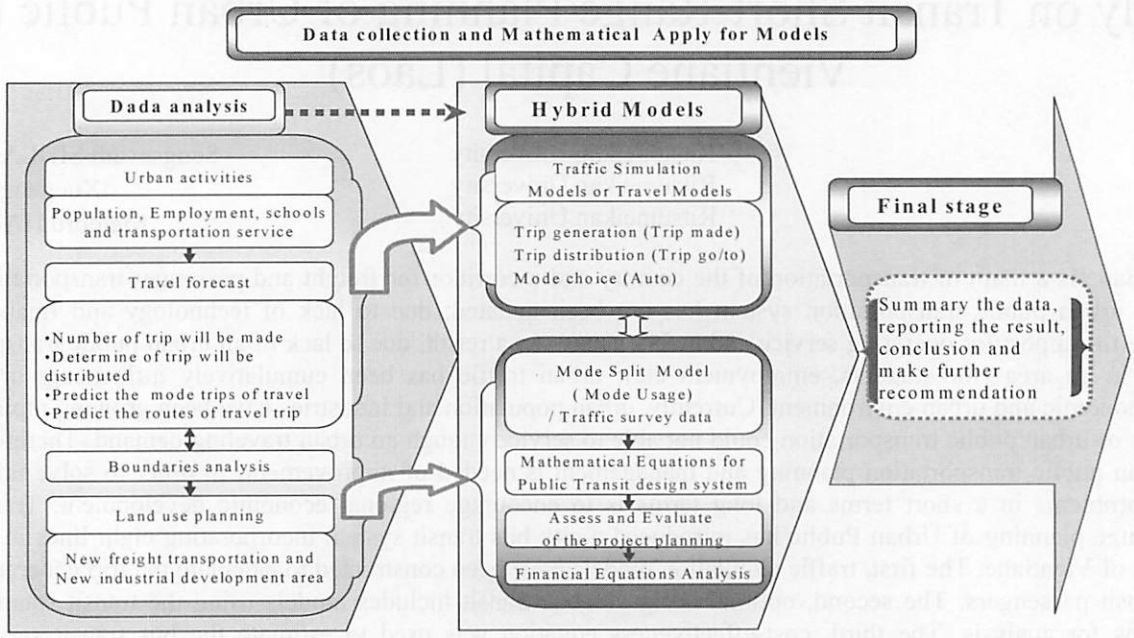

Figure 2: Mathematical Analysis Process

In general, transit service improvements in urban area include express bus service, frequent service, limited bus stop on routes, and central bus transfer. Thus, the central transfer has defined a particular area where many routes coverage with link schedules to improve continuation with a reduction of waiting time. For instance, in high residential or business centers, where traffic volumes are congested, the bus transit needs to separate roadway lanes for transit vehicles, which can improve bus travel time and schedule during rush hour.

3. Research Process and Mathematical Formulation

The first stage of research has focused on data collection; discussed concepts of urban transportation analysis planning. Secondly, traffic simulation models are built up to analyze the forecasting urban passengers' travel. Then, it is calculated the result of urban travel trips estimation, automobile trips and public transit passengers forecasting on the routes planning. Finally, the optimal design of the city bus transit is concluded based on the models for estimating characteristic of bus operations which are used the standard equations for analysis.

3.1 Mode Choice Model (Mode usage)

-The characteristics of trip maker (e.g. Family income, number of autos available, family size, residential density)

-The characteristics of the trip (e.g. trip distance, time of day)

-The characteristics of the transportation system (e.g. riding time, excess time)

-Direct-Generation Usage Modes

$$P_i = \frac{e^{V(i)}}{\sum_{r=1}^{n} e^{V(r)}} \tag{3-1}$$

V (i) =Utility of mode i; V(r) =Utility of mode r; n= number of modes in consideration

3.2 Cost Effectiveness (Evaluated)

$$I_1 = \frac{\Delta C_1 + \Delta C_2 - \Delta T_1 - L}{\Delta R} \tag{3-2}$$

ΔC_1 = Difference in annualized capital costs (from TSM option); $\Delta C2$ = Difference in annual operating and maintenance costs (from TSM option); ΔT = Monetary value of annual time savings to existing transit riders (over TSM option); L= Annual local contribution; ΔR = Difference in annual rider ship (from TSM); I_1 = Cost-effectiveness index

3.3 User Benefit Equation (Feasibility)

$$I_2 = \frac{\Delta C_1 + \Delta C_2 - L}{\Delta H_1 + \Delta H_2} \tag{3-3}$$

3.4 Bus Travel Time Equation

$$TT = T_f + N_s\left(T_s + T_{AD}\right) + T_D \tag{3-4}$$

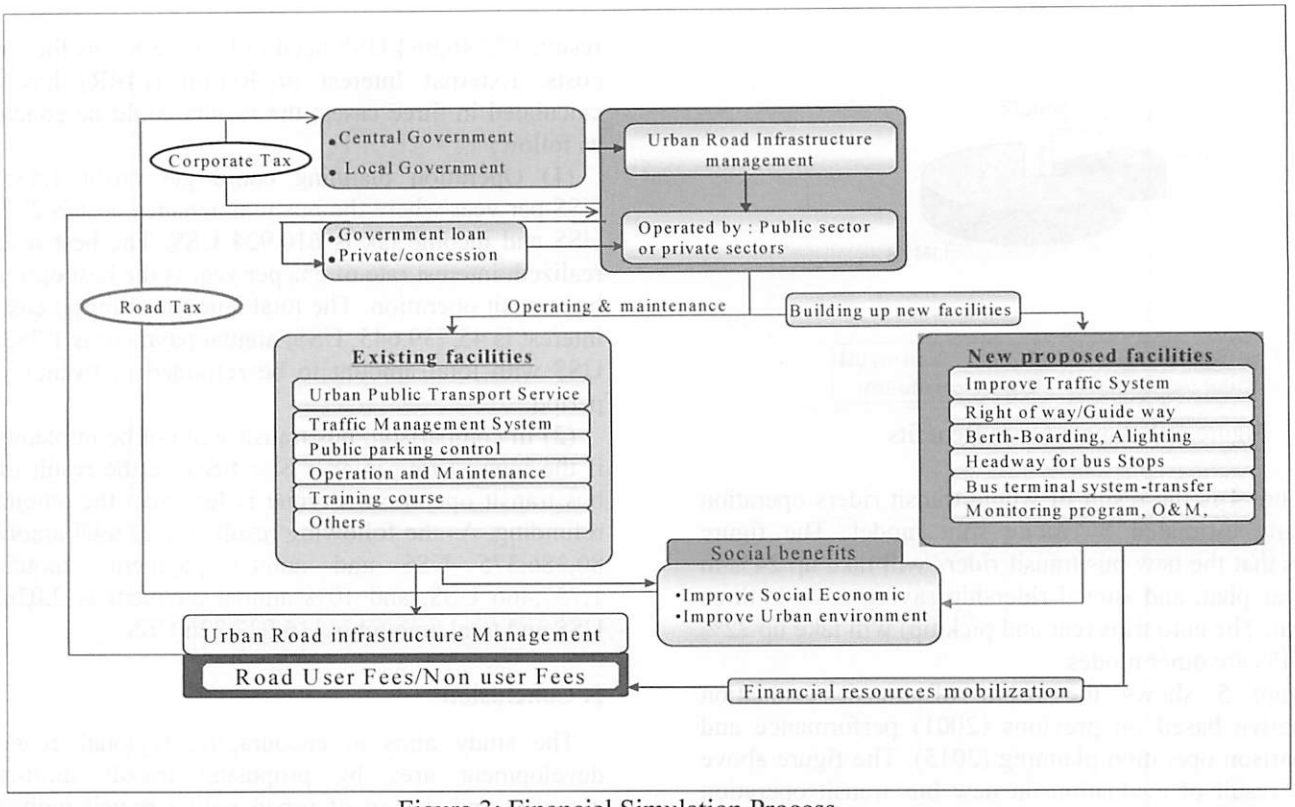

Figure 3: Financial Simulation Process

$$V = \frac{60}{TT} \tag{3-5}$$

T_f = Free flow travel time, minutes per km; Ts = Time spend at stops, minutes per km; T_{AD} = Time lost accelerating and decelerating, minutes per km; Ns = Number of stops per km; T_D = Traffic delays, minute per km; TT= total travel time, minutes per km; V=speed, miles per hour

3.5 Estimate Number of Buses Service

$$N = \frac{nL_R}{V} \times \frac{60}{h} \tag{3-6}$$

h= headway in minutes; V=average vehicle speed over entire route in km per hour; L_R = Round-trip length of route; n= number of cars per unit; N= number of individual transit unit (10% add waiting at terminal)

3.6 Head Way Policy Equation (H)

$$h = \frac{C_u}{P_{\max}} \tag{3-7}$$

$P_{\max}$ = The passenger demand on the maximum load link; C_u =passengers per transit unit;

4. Financial Simulation Process

In general, major urban transportation revenue should be charged from different sources of road infrastructure facilities in term of road user fees and non users fees as previous practice. Road user fees include taxes on fuel, vehicle registration and parking fees. Non user fees include property taxes and sales taxes. Funding return needs to get maximization from these various issues.

Figure 3 above shows the overview of financial simulation procedure based on the existing urban infrastructure facilities service and the proposed new facilities of bus transit short-range planning and design. Likewise, the transit planning and design has tried to identify improvement option and suggest directions in order to establish optimal or suitable new infrastructure facilities supporting bus transit operation service. Also, it is essential to provide technical information to support decision-makers' process of transit management and administration.

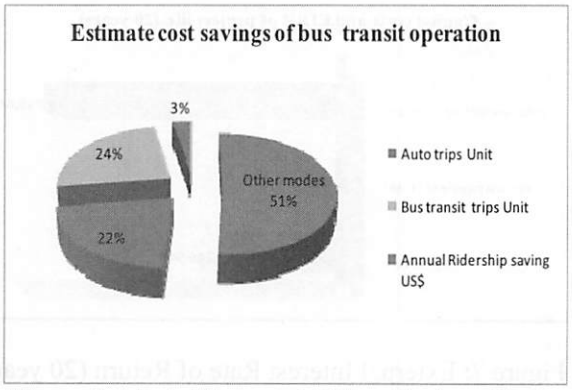

Figure 4: Mode Share and Riders Savings Cost

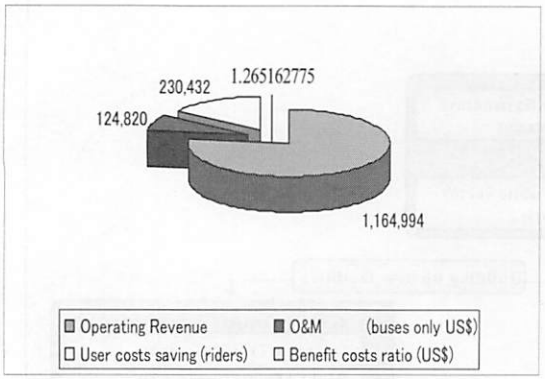

Figure 5: Estimate Costs Benefits

Figure 4 is the result of whole transit riders operation planning estimated by mode split model. The figure shows that the new bus transit riders will take up 24% in the year plan, and annual ridership saving costs is three percent. The auto trips (car and pick up) will take up 22%, and 51% are other modes.

Figure 5 shows the result of transit evaluation alternative based on previous (2001) performance and comparison operation planning (2015). The figure above is the result of evaluation on new bus transit operation simulation calculated by the cost effectiveness equation which has larger indicator. Based on the reference source operation planning could be implemented (E. Leggett, "Methodology For comparative Economic Analysis of Construction and TSM Alternative," *Institute of Transportation Engineers Journal,* August 1984.

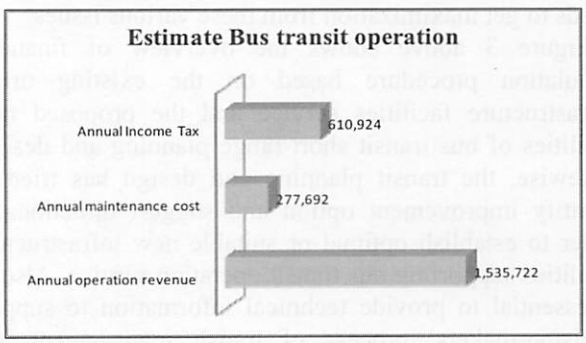

Figure 6: Bus Transit Operation Costs

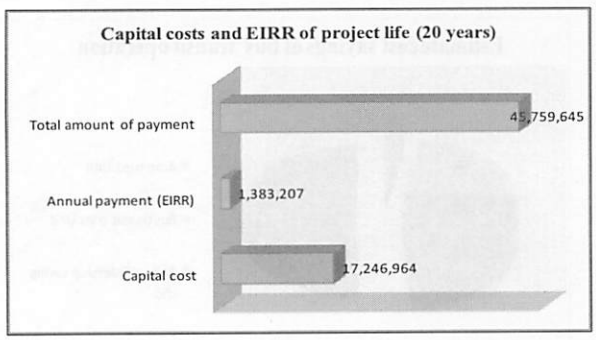

Figure 7: External Interest Rate of Return (20 years)

The capital costs include buses costs, terminals and platform of bus stop waiting except the road infrastructure and land are belong to government. As a result, 17,246,964 US$ need to be invested as the capital costs. External Interest of Return (EIRR) has been calculated in three cases; the results could be concluded as follow:

(1) Operation planning could get profit 1,535,722 US$ per year where the bus maintenance cost is 277,692 US$ and income tax is 610,924 US$. The best result is realized; interest rate of 5% per year is the best option for bus transit operation. The total amount of initial cost and interest is 45,759,645, US$; annual payment is 1,383,207 US$ with total amount to be refunded in twenty years period.

(2) In comparison, bus transit will not be implemented if the interest rate is over 8%; because the result of net bus transit operation revenue is less than the amount of refunding. As the following result, 8% of total amount is 80,386,375 US$ and annual payment amount is 1,757,466 US$, and 10% annual payment is 2,026,518 US$ and total amount is 116,027,226 US$.

5. Conclusion

The study aims at encouraging regional economic development area by proposing transit short-range planning and design of urban public transit with eight lines in six districts. In the study, various issues of transit operation have been considered. Mathematical models have been established; also traffic simulation models have been utilized for the analysis on urban travel and transit passengers forecasting.

The cost evaluation is calculated; the optimal design which includes models used the bus transit standard equations for analysis. The cost-effectiveness equation has been assessed which measure the bus transit operation service costs and cost saving on new transit riders. External Interest Rate of Return has been analyzed in order to assess for the feasibility operation planning in the project years.

In the future study, the accurate primary data is needed. Many parameters are applied with standard values for analysis. Also the various issues and factors need to be evaluated in the proposed public transit. As Vientiane Capital has been rapidly growing, urban expansion and industries and related urban traffic problems have influenced the social-economic and urban environment. Further research will work on the Urban Transportation Environmental Impact, to support the road infrastructure expanding project and improve the public transportation as a system.

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