PART IV

FEASIBILITY STUDY

CHAPTER 22

BUS SERVICE IMPLEMENTATION PLAN

CHAPTER 22

BUS SERVICES IMPLEMENTATION PLAN

22.1 BACKGROUND AND PURPOSE

The existing transport system in Phnom Penh is not sufficient to cope with the future urban transport demand of the city. This is one of the most serious urban transport issues to be addressed in the Master Plan Study for the future urban development and sustainability of urban environment in Phnom Penh.

Therefore, urban roads improvement, new roads development in the suburban area, traffic management, etc. are proposed in the Master Plan. Moreover, the bus is recommended as the most suitable public transport system in Phnom Penh.

The city of Phnom Penh has no mass public transit system and most of the citizens use private cars and motorcycles including the motodop (motorcycle taxi). The motodop is the main contributor of not only to the public transport modes because of its high level of service in terms of fare, frequency and door-to-door trips, but also to traffic congestion. It also poses a high risk of accidents. Convenience and cheap fare are more important than safety and comfort to Phnom Penh's citizens until now. But change in life style has opened the eyes of Phnom Penh's citizens to the importance of safety and comfort in the choosing of mode of transport. The success of the one-month bus operation experiment with more than 100,000 participants (passengers) testified to the fact that Phnom Penh citizens supported the comfort, convenience and safety of the bus as a favorable mode of transport.

Considering the above stated conditions, this chapter intends to study the most suitable bus system to cope with the transport demand in the year 2005 in Phnom Penh and to prepare the requirement for the introduction of the proposed bus system, which is to be the future trunk public transport system. It is envisioned that the bus system will be a great contributor to the vitalization of urban activities and the improvement of urban environment in Phnom Penh.

The results of the bus experiment, as described in Chapter 20, are utilized for this bus service implementation plan. The data used here includes demand forecast, fare system, required number of staff and bus operation plan.

Figure 22.1-1 Various Bus Systems in the World

22.2 WORK PROCEDURE

Work procedure of this chapter is shown in Figure 22.2-1. Figures in parenthesis show the section numbers of this Chapter.

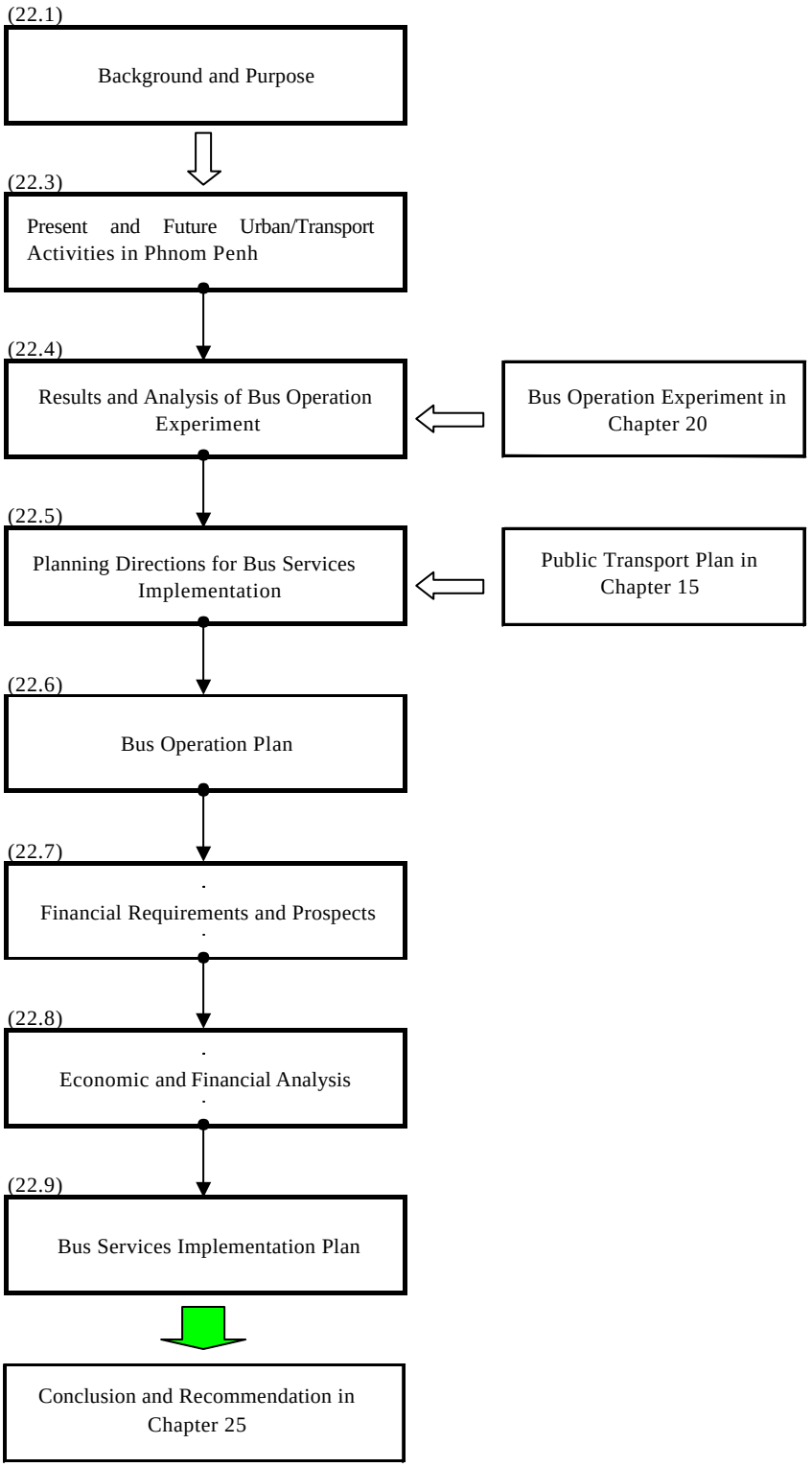


Figure 22.2-1 Work Procedures

22.3 PRESENT AND FUTURE URBAN/TRANSPORT ACTIVITIES IN PHNOM PENH

The characteristics of urban profile and urban transport of both present and future in Phnom Penh for the consideration of the bus system are as follows:

- Area and population
  - Year 2000 Total population: 1,152,000; four (4) Central Districts: 591,000 (51%) and the suburban area: 561,000 (49%)
    Total area: 434 km^2, 4 Central Districts: 27(6%) and the suburban area: 407(94%)
  - Year 2015 Total population: 1,820,000 (1.58 times of year 2000), 4 Central Districts: 750,000 (41%) and the suburban area: 1,070,000 (59%)
- Existing urbanized area has high density of population including a historically preserved district.
- The road network in the urbanized area is almost completed; however, the road pavement is deteriorated and the maximum number of lanes of thoroughfares is four (4) lanes. In addition, it is difficult to expand the road space in the urbanized area because of the highly dense land use.
- There is no mass public transport system. Motodop is the major public transport system in the city, because of its high level of service in terms of fare, frequency and door-to-door trips. Despite its popularity, its service poses a danger to drivers and passengers alike.
- Bus is operated only for international route and long distance by public and private sectors.
- Previously operated city bus was suspended due to the convenience of motodop, and bus service was interrupted by the heavy motorcycle traffic.
- Future increase rate of urban transport demand in 2015 will be 1.66 times the 2000 demand (from 3,240,000 trips to 5,380,000 trips). This is higher than that of population.
- Future direction of urban development is towards the west to cope with the future population of 1,820,000. Consequently, the average trip length will be longer than it is now and will necessitate the introduction of a public transport mode that is more suitable for longer trips than motodop.
- Basic planning directions of urban development in Phnom Penh are to vitalize the urban activities but maintaining the urban amenity. The deterioration of the traffic situation causes difficulty in maintaining urban amenity and urban activities.
- Phnom Penh City has difficulty in developing and maintaining the infrastructure on its own, because there is no appropriate taxation system in the city.
- Organization of the public sector is not functioning well.

22.4 RESULTS AND ANALYSIS OF BUS OPERATION EXPERIMENT

The accumulated total of bus passengers reached 103,239 during the one-month Bus Operation Experiment involving 2 bus lines, a 23-bus fleet and 88 staff. Major findings of the Bus Operation Experiment for the bus operation plan are summarized in Table 22.4-1.

Table 22.4-1 Major Findings of Bus Operation Experiment

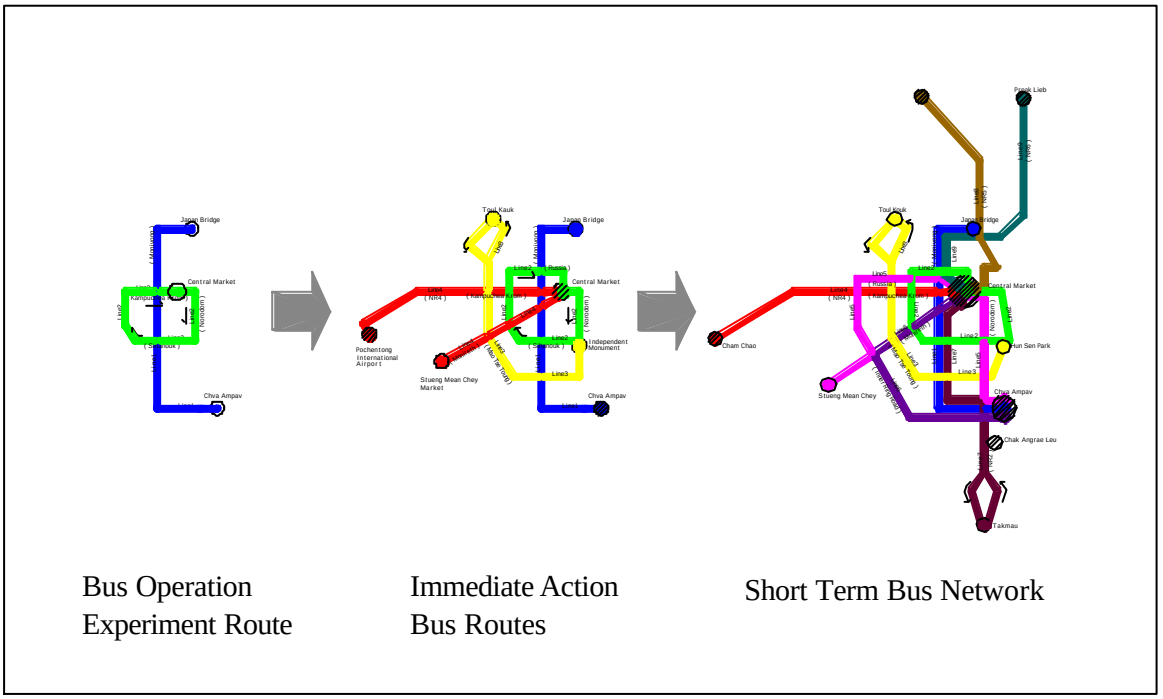
Items				Unit	Actual *1	Estimated *2
Number of passenger	One-month total		Line 1	passenger/ month	60,276	
			Line 2		42,963	
			Line 1 + 2		103,239	
		Daily average	Line 1	passenger/ day	2,009	
			Line 2		1,432	
			Line 1 + 2		3,441	
	500 riels flat fare		Line 1	passenger/ day	2,668	
			Line 2		2,019	
			Line 1 + 2		4,687	12,900
	800 riels flat fare		Line 1	passenger/ day	1,661	
			Line 2		1,077	
			Line 1 + 2		2,738	4,900
Passengers/bus	One-month total		Line 1	passenger/ bus/day	126	
			Line 2		206	
			Line 1 + 2		156	
	500 riels flat fare		Line 1	passenger/ bus/day	167	
			Line 2		288	
			Line 1 + 2		213	
	800 riels flat fare		Line 1	passenger/ bus/day	104	
			Line 2		154	
			Line 1 + 2		124	
Operational speed	Peak hour		Line 1	km/hour	13.4	10.3
			Line 2		11.7	10.8
	Off-peak hour		Line 1	km/hour	14.4	11.8
			Line 2		14.5	12.5
Fuel consumption			Line 1 + 2	km/liter	4.5	
Availability			Line 1 + 2	%	85	
Number of staff	Coordinator		Line 1 + 2	staff	2	
	Supervisor				3	
	Station master				4	
	Inspector				4	
	Ticketing and fare collection				3	
	Patrol along route				2	
	Driver				30	
	Conductor				30	
	Maintenance				10	
	Total				88	
	Staff/bus			staff/bus	3.3	

Note. *1: Actual figures from experiment
*2: Estimated figures before experiment

22.5 PLANNING DIRECTIONS FOR BUS SERVICES IMPLEMENTATION

Planning directions for bus services implementation are as follows:

- Basically, the bus route network presented here is that of the Short-term Plan of the Master Plan. In addition, the Immediate Action Bus Route Network, which is in between the network of Bus Operation Experiment and the Short-term Bus Network, is proposed, taking into consideration the successful outcome of the Bus Operation Experiment and aiming at the smooth implementation of the bus operation in the future. This is intended to avoid a big investment cost at the same time (refer to Figure 22.5-1).
- The bus route network of the Immediate Action Plan is designed to cope with the public transport demand inside the urbanized area in consideration of not only the current land use and road conditions but also the effective utilization of existing facilities, such as the terminal area along National Roads.
- The most serious problem of the bus system is the waiting time of passengers at bus stops. Therefore, it is necessary to minimize passenger inconvenience at the bus stops by giving enough information of bus operation and setting up bus shelters at transfer points and bus stops located near traffic generation facilities, such as markets and schools.
- Introducing a large-size bus fleet will affect the other modes of transport because the urban area is rather small compared with its population size and the maximum number of lanes, which is four (4), in case of the trunk roads. Large-size buses will also disturb the urban scenery, which is composed of historically unique low-level buildings. Therefore, it is necessary to introduce a small-size bus fleet in this bus operation.
- It is necessary not only to utilize and to revitalize the existing organizations for bus operation but also to establish an operationally and financially sustainable bus system.
- It is necessary to keep in mind the following basic concept for the planning of the public transport system, which was established at the Master Plan stage.
  - To consider a harmonized public transport operation between the bus and the existing para-transit mode, such as motodop (introduce the motodop zoning system and motodop operation as a feeder mode of bus); and
  - To consider a sustainable public transport system to maintain the urban amenity and urban activities (introduce a transportation-for-the-poor and environmentally friendly bus system).



Bus Operation Experiment Route | Immediate Action Bus Routes | Short Term Bus Network

Figure 22.5-1 Necessity of the Immediate Plan

22.6 BUS OPERATION PLAN

22.6.1 Bus Route Network Plan

In order to cope with the estimated traffic demand in the year 2005, a bus route network is designed in this study as the Short-term Plan of the Master Plan. This bus route network covers public transport corridors along radial and circular arterial roads, in the urbanized area and extends to the bus terminals along the arterial roads in the suburban area, such as National Roads 2, 3/4, 5 and 6. Taking account of this concept, as well as the effective bus route length, function of network and flexibility for the increase of demand, a bus route network composed of nine (9) routes is proposed as shown in Figure 22.6-1 and summarized in Table 22.6-1. As a transition between the bus route network of the Experiment and the above-mentioned Short-term Plan, it is proposed that there be an "Immediate Action Plan" for the smooth implementation of actual bus operation in the city. The structure of the Immediate Action Plan network only covers the urbanized area and comprises four (4) routes but encompasses most of trunk roads in the urbanized area except for the Inner Ring Road as shown in Figure 22.6-1.

22.6.2 Bus Stop, Bus Shelter, Terminal and Depot

(1) Bus Stop

Based on the result of Experiment, the location of transfer points and the experience of other countries concerning walking distance, which ranges from 300m to 500m, the bus stop intervals are planned at a distance of 300m for urbanized area and 500m to 1,000m for suburban area. In determining bus stop interval, the transfer point and the land use along the bus route are also considered. The information provided at the bus stop is important to minimize the inconvenience of the passengers waiting at the bus stop. Average stopping time at a bus stop is assumed to be about half a minute based on the Experiment result.

(2) Bus Shelter

To minimize inconvenience of the passenger at the bus stops, it is also necessary to set up bus shelters at transfer points and bus stops located near traffic generation facilities, such as markets and schools. Two types of shelter are planned in this study: the deluxe type and the conventional type. Selection of the type depends upon the estimated number of bus passengers at bus stop and the width of sidewalk.

(3) Bus Terminal and Turning Point

The terminals and turning points are among the most important facilities for the bus operation. They are planned to be provided at the origin/destination of each bus route. The bus terminal has many functions, such as waiting area for bus/passenger and a mode interchange area to facilitate passenger transfer between transport modes. The function of a mode interchange area necessitates an off-road space for the terminal, while, the turning point is planned on-road. In selecting turning points, space for waiting buses should be carefully considered as well as the width of road and traffic volume to allow smooth and safe turning of the buses. Based on the size of bus fleet (minibus) and the standards of other countries, it is proposed that the unit space of the bus terminal should be 75 sq. meter per bus in the urbanized area and 100 sq. meter per bus in the suburban area. (See Appendix A15～45 and A15～47 for the area necessary for bus terminals)

(4) Bus Depot

For the smooth operation of daily bus services, adequate maintenance of the bus fleet at the bus depot is necessary. The components of the bus depot are as follows:

- Bus maintenance garage for 10 buses

- Office space with headquarters function of bus operating entity
- Bus parking space at night time

22.6.3 Operational Factors to be Considered for the Bus Services

Bus operational factors such as operation period, operation interval, and operation speed, required number of buses and staff are discussed below based on the Bus Operation Experiment results and bus operation data of the World Bank.

- Operation period: 6:00 to 19:00 (13 hours)
- Operation interval
  Considering the land use along bus route and the peak period tendency of the road traffic, bus operation intervals are set to be between 5 to 15 minutes
  Peak hours: 7:00 to 10:00 and 15:00 to 18:00 (6 hours)
  The operation interval for bus routes in the urbanized area and well-developed suburban area is 5 minutes. For the others, such as the routes along NR 2, NR 5 and NR 6, it is 10 minutes.
  Off-peak hours: 6:00 to 7:00, 10:00 to 15:00 and 18:00 to 19:00 (7 hours)
  For bus routes in the urbanized area and along NR 4, the bus operation interval is 10 minutes and for the others, 15 minutes.
- Required number of buses
  Based on the bus route, operational factors and availability, the required number of bus for the Immediate Action Plan and the Short-term Plan are 75 and 175, respectively.
- Required number of staff
  Based on the staff per bus during the experiment and organization of the bus operation entity, the required number of staff for the Immediate Action Plan and Short-term Plan are 300 and 700, respectively.

22.6.4 Fare System

Considering the average trip length and fare of motodop passengers (3.4 km and 750 riels obtained from the traffic survey by the Study in 2000), the result of the Experiment and the route length of the proposed bus route network, it is proposed that a two-level and three-level fare system by distance for the Immediate Action Plan and the Short-term Plan be introduced, respectively. For the Immediate Action Plan, the suggested fares for trips under 5km and over 5km are 500 riels and 800 riels, respectively. The minimum fare is decided by the fare sensibility analysis, which is the analysis on the relation between bus passenger demand and fare revenue, as shown in Figure 22.6-2. It may also be necessary to consider a lower fare than motodop because there are some disadvantageous elements of bus usage compared with motodop usage, especially for the short distance trip. And it is advisable to introduce season tickets and coupon tickets to increase the bus passengers in the future.

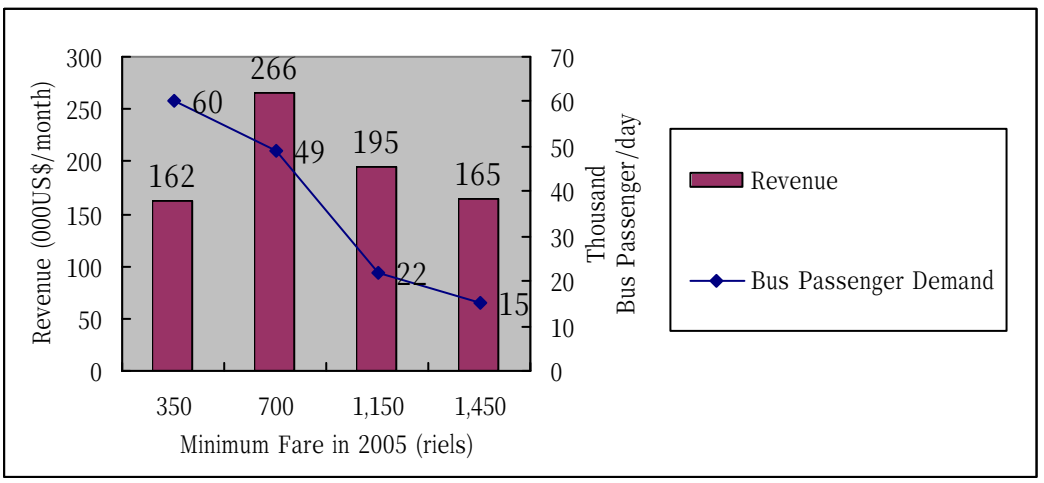


Figure 22.6-2 Relation between Bus Passenger Demand and Fare Revenue by Fare Level

22.6.5 Bus Passenger Demand

Bus passenger demand is estimated based on (i) the result of the analysis of opinion survey of bus operation in the person trip survey, which covered more than 30,000 samples, (ii) the proposed bus routes and (iii) the population by zone. Also considered for this exercise is transfer passengers from mode interchange areas such as intercity bus terminals, e.g. Chbar Ampauv market and Pochentong International Airport to city bus.

Taking the above-mentioned factors into account, the estimated daily number of bus passengers for the Immediate Action Plan and Short-term Plan is approximately 24,000 and 49,000, respectively. If a transport policy such as motodop operational zone system would be introduced, more passengers would be expected (over 100,000 passengers/day for the Short-term Plan). However, no such transport policy is assumed here because this needs social consensus and improvement of operation environment for motodops such as improvement of pavements of collector/local streets. The possibility of such social consensus is not certain at this moment and it is conservative not to assume such transport policy will be implemented. Details of this demand forecast are presented in Appendix 22.6. An alternative bus passenger demand analysis by disaggregate model is described in Appendix A20.2-4[*]. Based on this analysis, the estimated daily number of bus passengers for the Immediate Action Plan and the Short-term Plan is approximately 24,000 and 37,000, respectively. Comparing the results between the analysis of opinion survey and disaggregate model, the daily number of bus passengers for the Immediate Action Plan is almost the same but the number of passengers for the Short-term Plan by the analysis of opinion survey is higher than the result by disaggregate model. This study uses the higher estimate because more passengers can be expected by adopting various measures, such as the introduction of season tickets and coupon tickets.

22.6.6 Other Countermeasures

Considering the transport characteristics in Phnom Penh, direct and indirect measures to increase bus passengers demand should be introduced upon due consideration. These measures are listed below:

- Improvement of time schedule of bus operation such as coordinated time schedule between buses;
- Improvement of type of bus service such as introduction of luxury buses;
- Establishment of transfer system between other modes of transport such as park and bus ride system; and
- Introduction of motodop operational zone system.

[*] The results of these two estimates showed similar values. The method of Appendix 22.6 was adopted because the data were collected from wider area than those of the Public Experiment.

Table 22.6-1 Bus Operation Plan

Items		Unit	Routes		Remarks
			4 routes	9 routes	
A	Route length	km	36	92	
B	Passenger demand	passenger/day	23,750	49,360	
C	Type of bus		Minibus (45 passenger)		
D	Daily passenger per bus	passenger/bus/day	400		
E	Number of bus	unit	64	148	
F	Availability	%	85		
G	Requried number of bus	unit	75	175	
H	Number of staff per bus	staff/bus	4		
I	Total number of staff	staff	300	700	
J	Number of bus stop	unit	150	300	300 - 1,000m
K	Number of bus shelter	unit	40	90	
L	No. of waiting bus	unit	14	14	
M	Bus waiting space	sq. m	1,050	1,050	
N	No. of bus in CBD terminal	unit	19	56	Including off-road waiting space at Stueng Mean Chey
O	CBD terminal area per bus	sq. m/bus	75		
P	Existing bus terminal in CBD	sq. m	1,425	4,200	
Q	No. of bus in suburban terminal	unit	13	34	
R	Suburban terminal area per bus	sq. m/bus	100		
S	Existing bus terminal in suburban are	sq. m	1,300	3,400	
T	No. of bus at depot	unit	49	94	
U	Depot area per bus	sq. m/bus	75		
V	Total area of depot	sq. m	3,675	7,050	
W	No. of staff in the office	staff	150	350	
X	Office space per staff	sq. m/staff	15		
Y	Total area of office space	sq. m	2,250	5,250	

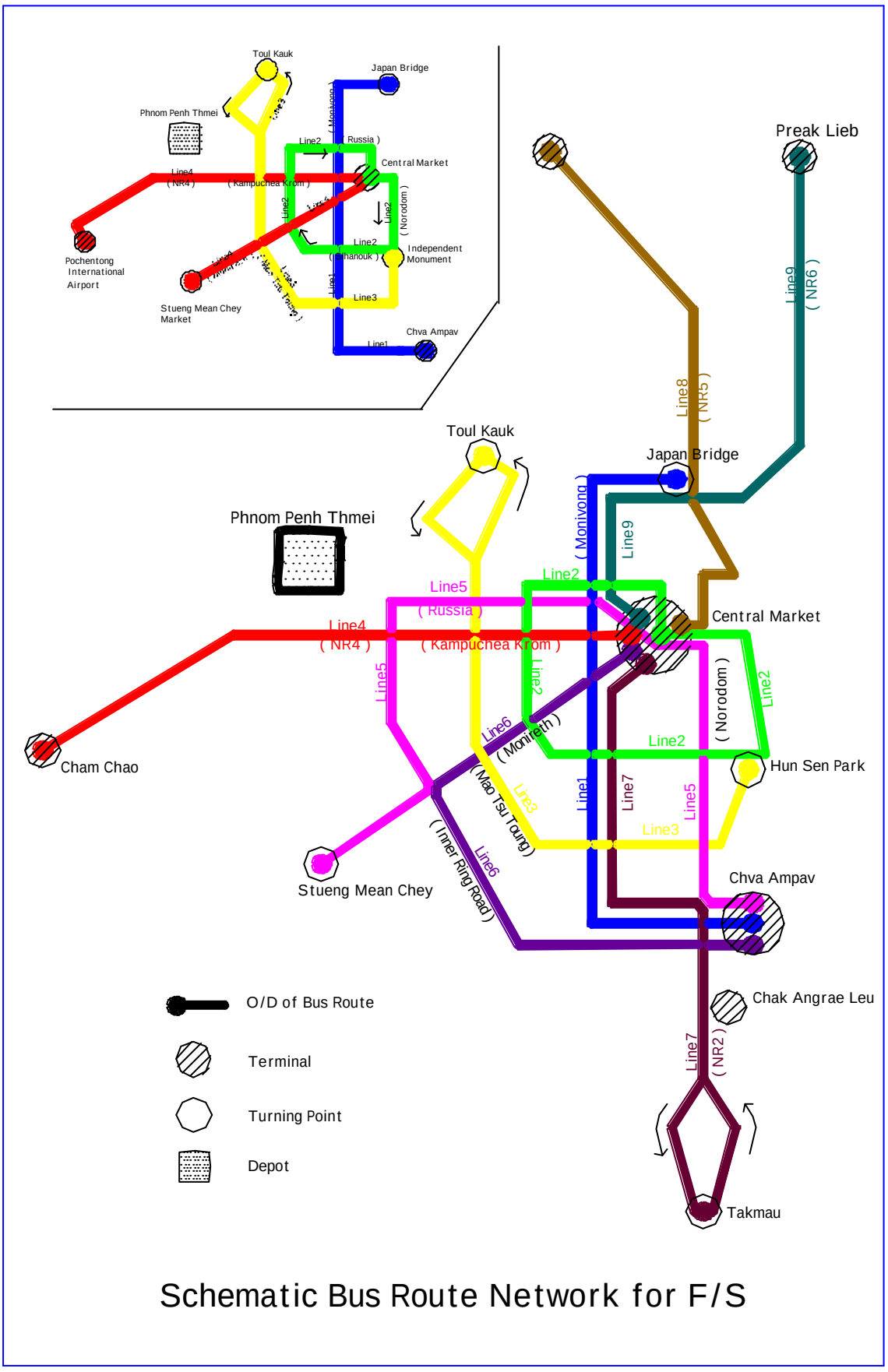


Figure 22.6-1 Proposed Bus Routes for the Study

22.7 FINANCIAL REQUIREMENTS AND PROSPECTS

22.7.1 Financial Requirements and Prospective Resources

The Study estimates the cost of the public bus transport service. Financial requirements are estimated as follows:

Table 22.7-1 Project Cost: Foreign and Local Components

Unit: US$1000

Items	Features	Required Financial Amount		
		Total	Foreign	Local
Bus	175 buses	11,200	11,200	
Office		1,050		1,050
Depot		500		500
Bus stop		76		76
Bus shelter		180		180
Engineering cost		600	600	
Total		13,606	11,800	1,806

The amount of fund required varies depending upon the type of operating entity. The sources of fund are classified into official grant aid and loan extended by international and bilateral financial institutions, private sector resources and the government budget.

The Study reviewed the fund raising potentiality of the following six types of entities for bus operators; A) direct operation by public sector, B) indirect operation through public corporation, C) public operation with contract-out arrangement to private sector, D) operation by third sector, E) operation with BOT basis and F) operation by private sector. These entities were evaluated financially considering investment climate, scarcity of government budget and interest of the private sector in the project in the next 5 years. The result of evaluation is shown in Table22.7-2.

Table 22.7-2 Financial Evaluation by Type of Entity

	A) Direct operation	B) Indirect operation	C) Contract -out	D) Third sector	E) BOT	F) Private
Official Grant	P	P	X	X	X	X
Official Loan	X	X	X	X	X	X
Private Sector	X	MP	MP	MP	MP	X
Government Budget	X	X	X	MP	X	X

Remarks: P = Possible, MP = May be possible, and X = Impossible
Official Loan requires government guarantee for repayment.

22.7.2 Local Financing

The Municipality of Phnom Penh (MPP)

Financial resources of MPP are very limited. MPP does not have enough budgetary room for investment in a public bus transport service in the city. In addition to the need for capital investment, MPP should also develop human resources to implement the project within the coming three (3) to four (4) years if they plan to implement the project.

In many cities other than in Cambodia, bus services are subsidized, if necessary, with the government fund. Basic idea for this type of subsidy is that bus services provide the general public with various benefits such as alleviation of traffic congestion and reduction in air pollution.

In case of Phnom Penh, however, the Government is in severe shortage of fund as described in Chapter 8. For example, "Operational Expenditure" of DPWT, MPP is less than US$100,00 for

average year, except for year 2000 (Table 8.2-5). In contrast, the amount of fund required for the proposed bus operation exceeds US$13 million (Table 22.7-1).

In view of this serious shortage of Government resources, the Study recommends that MPP request through the national government foreign official grant aid for the project. The request for grant aid should cover not only the cost of buses but also an office, a depot with maintenance equipment, and the cost of hiring engineering experts. Moreover, the request for official grant aid should be sought for the initial stage of the project amounting to US$ 6.3 million. The project cost includes the items shown in Table 22.7-3 as proposed in the Short-term Plan for 2005.

Table 22.7-3 Project Cost for Initial Stage of the Project

Unit: US$1000

Items	Features	Required Financial Amount		
		Total	Foreign	Local
Bus	75 Buses	4,800	4,800	
Office		525	525	
Depot		250	250	
Bus stop		38		38
Bus shelter		80		80
Engineering Cost		600	600	
Management & Operation	For initial three months	1,068		1,068
Total		6,293	6,175	118

It is considered that, following the Bus Operation Experiment and its continuation throughout July 2001 with its own fund, the MPP accumulated valuable experience about bus operation/ management. The local cost mentioned above will be less should the MPP utilize these facilities.

The Cambodian Government

The Cambodian Government also has budgetary constraints and will be unable to appropriate funds for the public transport project out of its budget in the near future.

The Government, however, should provide incentives like exemption of customs duties on imported buses and free use of lot or low lease rate on the lot to be leased to bus transport services in order that fares for the services could be set at a low rate and thus increase the sustainability of the project.

As the Study recommended in Section 19.2.3 of Chapter 19, the Government should adopt measures to raise financial revenue that is applied specifically for development of the public transport sector. Since the Government does not have special budgetary fund to invest and promote public transport, it is recommended that the request for foreign assistance include local cost financing as much as possible.

22.7.3 Foreign Financing

Official Grant for Bus Transport Services

An official grant should first be considered and be requested by the Government. However, it should be noted that the amount of the official grant is very limited and is not enough to implement a big project. For this project, under an official grant, it is not necessary to depreciate the cost for repayment but rather it is necessary to depreciate the cost for future procurement of buses after the present or first batch of buses have become obsolete and unsuitable for use (it is expected that with proper maintenance the lifespan of buses is 10 years after the first service).

Official Development Loan/Credit

Official development loans/credits are available it can cover more than 60% of the total project cost. Especially the Japanese ODA loan could provide up to 85% of the cost including local cost, if competitive procurement is applied. However, the feasibility and sustainability of the project should be evaluated in detail taking into consideration many aspects of the Project such as

commercial, financial, organizational, technical, economic, environmental, legislative, and institutional aspects. The terms and conditions of the loan vary depending upon the lending organization, but it is concessionary lending with low interest rate and a longer repayment period. The ability of the Government to repay the loan principal and interest is another aspect to be evaluated. The capability of officials implementing the project should be developed beforehand and, in the course of the project implementation, continued with the transfer of technical knowledge by the consultants. The Study thinks the absorptive capacity of the Government and MPP is so weak that within the coming three to five years to come, human resources development with institutional building is required.

22.7.4 Private Investment under the BOT Scheme

The Government has established several schemes to attract foreign direct investment in infrastructure projects, which includes the public transport sector. The schemes themselves are thought to be attractive enough for foreign investors, compared with those of other Asian countries, but other aspects of the investment climate in Cambodia are considered to be very risky without the proper legislative institution to support and promote the public bus transport business. The Study recommends that the Government and MPP request technical assistance with official grant aid to promote private participation in the public transport sector as proposed in Section 19.3 of Chapter 19.

Moreover, the Study recommends that the Government and MPP seek official grant aid assistance for the Short-term Plan up 2005. For the rest of the project financing the government should seek other resources such as a combination of local, foreign, and international financial institutions within the next five years. Meantime, for the smooth implementation and sustainability of the project it is urgently required for the Government to establish legal and financial institutions with the technical assistance of foreign consultants under official grant aid.

22.8 ECONOMIC AND FINANCIAL ANALYSIS

Basically there are two (2) groups of opposite beneficiaries attributable from implementation of a public transport project. One is an entity that carries out the project implementation, by investing a large amount of fund in a fairly short time span, and receives revenue and earnings accrued during the project life after its completion. This group can be divided into several entities, like public or private project executing body, implementing contractor, and transport service operator. The other is the user of the improved transport service benefiting from project implementation, by paying a fare set forth by the transport administrator.

For project evaluation, it is necessary to identify the interrelationship of those involving in the transport project to clarify the standpoint of the evaluation. Also, there are other beneficiaries of the indirect effects of the project like business entities and the citizens located along the routes of the transport services that either receive benefits in terms of increase in land prices have reduced costs to maintaining existing environmental conditions.

- Basic Assumptions
  Economic and financial analyses are made with the comparison of two cases; case where the bus services are introduced (With-Case), and the case where the bus services are not introduced (Without-Case). Preconditions for the analysis are as follows;

  - Analysis period is 20 years after bus services are started (considering life period of buses).
  - Quantified benefits for economic analysis are savings in vehicle operating cost and savings in travel time (see Table 13.2-14 for calculation of travel time cost).
  - Revenue for the financial analysis are bus fare revenue and advertisement fee (Appendix 22.8-1).
  - It is assumed that the bus fleet comprises 75 units in 2004 and 175 units for the next 10 years following 2005.

- The useful life of assets are assumed to be 10 years for the bus fleet and 20 years for office and depot facilities.
- Discount Rate is 12% p.a. (Typical value for developing countries)
- Project costs are shown in Table 22.8-1.
- Direct Operational Costs and Administration expenses are shown in Table 22.8-2.

Table 22.8-1 Project Costs Unit: US$1,000

Project Cost	2002	2003	2004	2005	Financial Cost	Economic Cost
Bus		4,800	6,400	-	11,200	*
Office		525	525	-	1,050	922
Depot		250	250	-	500	413
Bus Stop		38	38	-	76	64
Bus Shelter		80	100	-	180	154
Facilities Total		5,693	7,313	-	13,006	1,553
Engineering Cost	400	150	50	-	600	600

Table 22.8-2 Operating Costs Unit: US$1,000

Operating Cost	2002	2003	2004	2005	Financial Cost (in 2005)	Economic Cost (in 2005)
Direct Operational Cost						
Personnel	-	-	380	879	879	*
Fuel	-	-	230	533	533	*
Maintenance	-	-	92	213	213	*
Depreciation	-	-	481	1,088	1,088	*
Insurance	-	-	46	140	140	140
Royalty	-	-	14	32	32	32
Direct Operating Total	-	-	1,243	2,885	2,885	172
Adm. Expenses	-	-	620	1,035	1,035	506
Total Expenses	-	-	1,863	3,920	3,920	678

Note: Cost of bus fleet, operational staff salaries, fuel and depreciation are not included in the economic cost because these are included in the traffic cost.

22.8.1 Economic Analysis

1) Estimate of Benefits

The project evaluation in this section aims at the comparison between the case with project implementation and the case without implementation specified as Alternative 1 in Chapter 13 where modal share of the future transport is assumed to remain almost the same as present.

The Study confines the economic analysis based on the project benefits in terms of decrease in vehicle operating cost and time saving value with the costs for initial investment, operating and maintenance. (See page 13～26～28)

Table 22.8-3 shows the comparisons of traffic parameters. It was assumed that the road traffic capacity would not be reduced and motodop and private motorcycle capacity be adequately adjusted. The benefits of the bus users who have diverted from motodop users and road users are composed of the following:

a) Savings in vehicle operating cost due to the higher vehicle occupancy than existing motodop and private car use.
b) Savings in travel time due to the reduction in traffic congestion.

Table 22.8-3 Comparisons of Traffic Parameters

Year 2015	Veh – km				Veh - hr				Traffic Cost
	Car	Motorcycle	Truck	Bus	Car	Motorcycle	Truck	Bus	
W/O	74,214	171,822	86,515	538	19,597	33,680	35,755	1,733	423,854
With	71,722	152,033	83,497	8,772	18,988	25,815	34,687	12,084	408,598
Diff.	2,492	19,789	2,018	-8,234	609	7,865	1,068	-10,352	15,256

2) Benefit Indication

The results of benefit indication for the Short-term Plan on 9 routes by 175 buses are as follows. Net Present Value (NPV) and Benefit-Cost Ratio (B/C) with discount rate of 12% are calculated at US$4.1 million and 1.38 respectively for a 20 year period. Details of the analysis is shown in Appendix 22.8-1. The corresponding value of the Economic Internal Rate of Return is calculated as 20.4. These figures are generally regarded as economically acceptable for project implementation.

Sensitivity analysis

To see the influence of deviations in cost and benefit from the assumed conditions, sensitivity analysis was made for the following two (2) cases.

Case 1 : Cost 10% increase, benefit 10% decrease
Case 2 : Cost 10% decrease, benefit 10% increase

The result of the analysis is shown in Table 22.8-4.

Table 22.8-4 Result of Sensitivity Analysis

Parameter	Base Case	Sensitivity Analysis	
		Case 1	Case 2
B/C Ratio	1.38	1.12	1.68
EIRR (%)	20.38	15.36	25.08
NVP (US$1,000)	4,129	1,529	6,728

22.8.2 Financial Analysis

1) Estimate of Revenues

It is assumed that the revenue source of the project are bus fare and advertisement fee. As analyzed in Section 22.6, the bus fare is set up 500 riel, 800 riel and 1,000 riel in accordance with trip length. For this financial analysis, but fare is assumed to be 700 riel per passenger trip with a 49,360 passenger demand in year 2005, based on sensitivity analysis described in Section 22.6. The fare shall be maintained for 5 years and increased every 5 years in accordance with the GDP growth rates.

The result of the revenue estimation based on the fare rates and passenger demands described above are shown in Table 22.8-5.

Also the other revenue sources, which are advertisement on bus, bus stop and bus shelter, are considered in this Study. The percentage of buses assumed to earn income from advertisement is 40% of the total fleet and for both bus stop and shelter 50% of the total units are assumed to be used for advertisement purposes.

Table 22.8-5 Estimates of Bus Revenues

	2004	2005	2010	2015
Number of Bus (Fleet)	75	175	175	210
Passenger Demand (Passenger)	22,960	49,360	58,400	67,700
Bus Fare (Riel/passenger)	500	700	1,000	1,400
Bus Revenue (US$/Day)	2,940	8,860	14,970	24,300

2) Financial Assessment

The FIRR for the Short-term Plan is calculated at 1.7%. NPV and B/C with discount rate of 12% are calculated at minus US$9.5 million and 0.8 respectively for a 20 year period. (See Appendix A22.8-2 for details of analysis)

Sensitivity analysis

Sensitivity analysis was made for the case of increase/decrease in the bus fare. (See "26.2.4 Far System" for the relation between fare and total revenue)

Case 1 : bus fare of 350 riels
Case 2 : bus fare of 1,150 riels

The result of the analysis is shown in Table 22.8-6.

Table 22.8-6 Result of Sensitivity Analysis

Parameter	Base Case	Sensitivity Analysis	
		Case 1	Case 2
B/C Ratio	0.80	0.61	0.51
FIRR (%)	1.70	*	*
NVP (US$1,000)	-9,500	-19,377	-24,254

* FIRR cannot be calculated.

The annual revenue and cost stream for 10 years is also calculated as shown in Table 22.8-7.

Table 22.8-7 Annual Revenue and Cost Unit: US$1,000

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Revenue										
Bus Fare	1,060	3189	3,299	3,412	3,529	3,650	5,393	5,555	5,722	5,894
Advertise.	-	351	351	351	351	351	492	492	492	522
Total	1,060	3,540	3,650	3,763	3,880	4,001	5,885	6,047	6,214	6,416
Expenses										
Direct	1,243	2,886	3,358	3,549	3,755	3,979	4,222	4,436	4,663	5,303
Indirect	620	1,035	1,133	1,183	1,238	1,298	1,362	1,580	1,652	1,780
Total	1,863	3,921	4,491	4,732	4,993	5,277	5,584	6,016	6,315	7,083
Profit/Loss	-803	-381	-841	-969	-1,113	-1,276	301	31	-101	-667
Cost Ratio	176%	111%	123%	126%	129%	132%	95%	99%	102%	110%

Results of the calculation show extremely low values. Thus bus operation is judged to be not feasible. Therefore, a comparison of the financial viability by type of business entity is attempted as discussed n Section 22.7, in terms of monthly profit and loss in 2005.

Table 22.8-8 Viability Comparison of Operational Entities Unit: US$1,000

	A (G. Direct)	B (G. Indirect)	C (Contract Out)	D (3rd Sector)	E (BOT)	F (Private)
Initial Investment	13,005	255	13,005	11,484	13,004	13,004
Revenue (1)	295	295	295	295	295	295
Direct Cost	262	262	227	265	265	265
Indirect Cost	72	28	72	101	172	172
Total Expenses (2)	334	290	299	366	437	437
Profit/Loss	-39	5	-4	-71	-142	-142
Cost Ratio (%)	113%	98%	101%	124%	148%	148%

As a result of this comparison, type B, which is indirect operation through public corporation, is found to be the only financially positive entity. However, strong Government support, such as the preparation of land for the bus terminal and depot

construction, together with provision of the bus fleet by the national and/or local Government, is essential for this entity to be financially viable.

3) Review of Bus Operation Potentiality by Other Entities

The review of bus operation potentiality by other entities is also attempted referring to the World Bank data on city bus. As the data indicate, other than Option B, representative entities currently adopted in most of the cities in the world are Options A and F. The review on potentialities of bus operation by the selected two (2) options shows negative results as follows:

Option A: Direct public operation
This option is deemed effective in those cities whose tax collection system is functioning, because it is necessary that the public transport in place, meeting the transport demand, should operate at reasonable fares to provide transportation to the poor (MPP has no adequate tax collection system).

Option B: Direct private operation
Main objective of this option is profit making, and tends to give little attention to requirements of the society and traffic demand.

22.9 BUS SERVICES IMPLEMENTATION PLAN

22.9.1 Project Frame

Based on the bus passenger traffic demand, the cost frame as shown in Table 22.9-1 for bus service implementation project in the Short-term Plan in 2005 catering for 9 routes with a fleet of 175 buses is formulated as follows with the details shown in Table A22.9-1 in Appendix A22.9.

Table 22.9-1 Cost Frame of Bus Service Plan

Unit: US$1000

Component	Immediate Plan	Short-term Plan	Total
Basic Design	600	0	600
Bus Fleet Procurement	4,800	6,400	11,200
Bus Facility Improvement	893	913	1,806
DPWT & PPT Consulting	0	1,200	1,200
Total	6,293	8,513	14,806

22.9.2 Conditions for Project Realization and Optimum Bus Operator

(1) Project Realization Conditions

The economic and financial evaluations of the Project carried out in Section 22.8 show that the Project is economically viable with EIRR of 20.4%, NPV of US $4.13 million and B/C ratio of 1.38, but the financial feasibility is not high with the value of FIRR of 1.7, NPV of minus US $9.5 million and B/C ratio of 0.81.

For the realization of the Project, the Study attempted to determine possible and practical means to implementing the urban bus services which are indispensable to Phnom Penh. The conclusions made and the conditions identified for project implementation are as follows:

- The Project shall be executed and operated by the Government as the fundamental transport services to stimulate the social and economic activities of the citizens of Phnom Penh. (The Government here means the MPP)

- The project needs grant-aid type financial support for procurement of the bus fleet and spare parts which are the major cost components of the Project, and
- The Project shall be implemented in two phases because even the Short-term Plan requires quite a large number of buses and a huge investment with a corresponding organizational structure, and it is advisable to start operation on a smaller scale on a pilot-operation basis. The pilot-operation is intended to acquire enough operational experience and know-how, and locomotive power to smoothly step up to the Short-term Plan and to avoid risky investment and failure.

(2) Bus Operator

The most important factor for success of the project lies in the eligibility of the bus operating entity and its performance efficiency to maintain the sustainability of operation. For this purpose the Study carried out a suitability assessment by type of business entity as shown in Table 22.9-2 for determination of the optimum entity (the assessment by financial aspects is shown in Table 22.7-2 and Table 22.8-7). The assessment result shows that the most suitable type of business entity will be Case B: bus services operation by an autonomous body, "Phnom Penh Transport Authority (PPT)" which belongs to the DPWT, MPP.

The result also shows Case C, where the MPP will make an arrangement to contract-out to the private entity for bus operations, can be viable. But with this arrangement, the MPP cannot guarantee a satisfactory level of service to the passengers and cannot ensure proper maintenance of the bus fleet. Furthermore, the private operator tends to seek only the profitability of the business; therefore it is expected that private operators will show little interest in this arrangement.

Table 22.9-2 Bus Business Suitability Assessment by Type of Entity

Type	Sectoral Category	Type of Operation	Property Ownership	Supervising Organ	Suitability by Type of Business Entity																Evaluation	
					Fund Raising Capability		Laws/Regulations		Cost Consciousness		Operational Advantage		Maintenance Capability		Profitability		Total Value	Rank	Reason
A	Public	Directly by TO, DPWT	MPP	TO, DPWT	can raise fund when determined by government policy		easy by draft out applicable regulations to be submitted for approval		much lack of cost consciousness		should newly employ professional staff		should newly employ professional staff		can not expect profit making by this entity		19.0	**4**	Not recommended: business directly by public can not be recommended and does not pay at all
					○	5.5	○	5.5	×	1.5	×	2.5	×	2.0	×	2.0						
B	Public	By TAPP	MPP	TO, DPWT	can raise fund when determined by government policy		has advantage for adaptation and follow		may lead to cost consciousness		directly operate or partially contract out		may directly operate or partially contract out		may lead to profitability by effective management		30.0	**1**	Recommended: autonomous entity of TAPP already engaged in operation and by reforming organization by manpower enforcing
					○	5.5	○	5.5	△	3.0	○	6.0	○	5.0	△	5.0						
C	Public	Contract out to private bus operator	MPP	TO, DPWT	solely depend on intent of private operator		should follow applicable laws and regulations		very high cost consciousness		should follow instructions & guidance by administrator		can directly conduct maintenance activities		may lead to profitability by effective management		25.5	**2**	May be recommended: may lead to profitability while providing bus services
					△	3.0	△	2.5	○	5.0	△	5.0	○	5.0	△	5.0						
D	3rd Sector	By 3rd sector	MPP/ Private	TO, DPWT	hard to coordinate fund raising between public & private partners		should follow applicable laws and regulations		very hard to introduce cost-mind among public & private partners		may conflict on operational policy among partners		should newly employ professional staff		may lead to operational loss by conflict among partners		11.5	**6**	Can not be recommended: not keep sustainability
					×	1.0	△	2.5	×	1.5	×	2.5	×	2.0	×	2.0						
E	Private/Public	By private operator	Private/ Public	TO, DPWT	solely depend on intent of private operator		should follow applicable laws and regulations		high cost consciousness		less advantage on business license & regulations		should newly employ professional staff		may lead to operational loss by burden from operational conditions		17.0	**5**	Might be possible but not recommended: volunteer can not be expected
					△	3.0	△	2.5	○	5.0	×	2.5	×	2.0	×	2.0						
F	Private	By private operator	Private	TO, DPWT	solely depend on intent of private operator		should follow applicable laws and regulations		very high cost consciousness		less advantage on business license & regulations		can directly conduct maintenance activities		may lead to profitability by effective management		23.0	**3**	May be possible but not recommended: too much uncertainty of conditions
					△	3.0	△	2.5	○	5.0	×	2.5	○	5.0	△	5.0						

Remarks: 1. Business suitability for each column is assessed first by the marks indicated by ○, △ and X for 6 types, which are then converted to numerical values ranging from 6(highest) to 1 (lowest) so that the column total comes up to 21. When the same mark shares several types an average numerical value is taken as the value of respective type.
2. TAPP=Transport Authority of Phnom Penh (former "Phnom Penh Transport Authority")
3. TO=Transport Office, DPWT

Regarding the bus operation, it would be imperative for the PPT to develop management

know-how on bus transport business and operations based on the management enhancement measures as follows:

- Introduction of business efficiency indicators as shown in Table 22.9-3, based on standard accounting and statistic systems,
- Introduction of bus operation and maintenance manuals, proposed in Appendix 22.9.4, along with a large scale reinforcement of its organization and staffing, and
- Assignment of an expatriate expert to work together with the management executives of the PPT for development and introduction of management expertise and operation manuals.

Table 22.9-3 Representative Business Efficiency Indicators

No.	Item	Unit	Equation (Calculation formula)	Remarks
A	**Transport Efficiency Indicators**			
1	Operating Bus Availability Ratio on weekly, monthly and yearly basis	%	Accumulative no. of operated buses / Total nos. of buses in possession x 100	greater the better
2	Operating Bus Distance Ratio by route on weekly, monthly and yearly basis	%	Total revenue distance of bus in km. / Total distance of bus traveled in km. x 100	greater the better
3	No. of Pax. Transported per day-veh. average per bus-day	person	No. of passengers per day / Total no. of operated buses per day	greater the better
4	Total revenue distance per day-veh. average revenue distance per day-veh.	km.	Total revenue distance of bus per day in km. / Total no. of operated buses per day	greater the better
5	Operational revenue per day-veh. average revenue per day-veh.	riel	Total operational revenue per day / Total no. of operated buses per day	greater the better
6	Operational expense per day-veh. average expense per day-veh.	riel	Total operational expense per day / Total no. of operated buses per day	greater the better
7	Operational profit per day-veh. average profit per day-veh.	riel	Total operational profit per day / Total no. of operated buses per day	greater the better (Item No. 5 - 6)
B	**Financial Efficiency Indicators**			
1	Net profit/net worth ratio net worth=liabilities + capital + surplus	%	Net profit in the period / Net worth in the period x 100	greater the better
2	Business profit ratio net worth=liabilities + capital + surplus	%	(Net profit+interest-tax) in the period / Net worth in the period x 100	greater the better
3	Personnel Expense ratio	%	Total personnel expense in the period / Total operational revenue in the period x 100	smaller the better
4	Fuel expense ratio	%	Total fuel expense in the period / Total operational revenue in the period x 100	smaller the better
5	Maintenance expense ratio	%	Total maintenance expense in the period / Total operational revenue in the period x 100	smaller the better

Remarks: 1. No. = number
2. Pax = passenger
3. Veh. = vehicle, bus

The historical and current operations, and proposed organizational structure in 2005 is presented in Appendix 22.9.5.

22.9.3 Implementation Schedule

(1) Prerequisites of Bus Service Introduction
As discussed in Chapter 14 in Part II, the prerequisites for the introduction of the bus service are as follows:

- Improvement of urban streets as proposed in Chapter 24 promote introduction of bus services,
- Development and streamlining of the legislative structures on land transportation of the Metropolitan Areas, as presented in Appendix A22.9.1, and
- Development of the expertise and know-how of bus operation business management, along with related organizational reform, so that it can yield net earnings enabling self-financing or at least maintain self-sustainability by enhancement of operational performance. The key measures are further discussed and presented in Appendix A22.9.2.
- For the long-term, introduction of a motodop operational zone system as proposed in Chapter 15, together with measures for increasing employment opportunities of the drivers of para-transit modes.

(2) Implementation Schedule

Based on the realization proposal presented in Section 22.9.2, the project is proposed to be implemented in the following two (2) phases:

- First Phase: Immediate Action Plan as pilot bus operation for one year in 2004: Bus passenger demand; 22,900 persons per day on 4 routes with 75 buses
- Second Phase: Short-term Plan for full introduction of the bus service from 2005: Bus passenger demand; 49,400 persons per day on 9 routes with 175 buses (additional 100 buses are procured)

The proposed implementation schedule is shown in Table 22.9-4.

Table 22.9-4 Bus Services Implementation Schedule and Annual Fund Allocation

Category	Item	2002	2003	2004	2005	2006
Phase	Type			Immediate Action	Short-term Plan	
	Bus Passenger Demand			22,900/day	49,400/day	
	No. of Route			4	9	
	No. of Bus			75	175	
Schedule	Basic or Detailed Design					
	Tender					
	Procurement					
	Operation					
Annual Fund Allocation	Basic Design	400	150	50		
	Procurement & Facility Improvement	0	4,800	6,400		
	Administrative & Bus Operator Consultings	0	893	913		
	Operation/maintenance	0	300	600	300	
	Total Project Cost (in US dollars in million)					
Related	Develop laws/regulations					
	Conduct training program		1st phase		(2nd phase)	
	Execute organization reform					(2nd phase)

Item	First Phase	Second Phase	Total
Basic or Detailed Design	0.60	0.00	0.60
Procurement & Facility Improvement	4.80	6.40	11.20
Management Consultings	0.90	0.90	1.80
Opertation & Maintenance	0.00	1.20	1.20
Total	6.30	8.50	14.80

Remarks: ═══ is for Immediate Action (Plan). ▬▬ is for Full-scale Operation

The operation expenses in 2004 and 2005 are estimated to be US$1.863 million and US$3.921 million, respectively.

(3) Operation and Financial Conditions

As discussed in the preceding section, implementation of the Immediate Action Plan with an investment cost for US $6.3 million is urgently needed for realization of the Short-term Plan. When the MPP is provided with the grant-type financial aid for procurement of 75 buses, the pilot bus service operation will be financially feasible with a profit of US$ 2.4 over a 10-year operational time span, as presented in the following Table 22.9-5.

Table 22.9-5 Revenue and Expense Stream of Immediate Action Plan (4 Routes, 75 Buses)

Year	Immediate Action Plan			
	Revenue	Expense	Balance	Acc. Balance
2003	0	0	0	0
2004	1,060	1,364	-304	-304
2005	1,535	1,364	171	-133
2006	1,587	1,449	138	5
2007	1,642	1,541	101	106
2008	1,698	1,643	55	161
2009	1,757	1,790	-33	128
2010	2,596	1,954	642	770
2011	2,674	2,071	603	1,373
2012	2,754	2,198	556	1,929
2013	2,837	2,460	377	2,306
2014	2,922	2,840	82	2,388
Total	23,062	20,674	2,388	-
E/R Rate (%)				90

If grant aid is to be extended to the first phase (Immediate Action Plan) of the Project, the project should be implemented in the following steps:

- Project Preparatory Study, to verify the needs, objectives and schedule of the project,
- Basic Design Study, to formulate a plan required for implementation of the bus service project including equipment procurement and related facility improvement plan,
- Procurement of buses and other equipment, and facilities improvement, and
- Management consulting services to the administrative agency on streamlining of legislative structure, and to the bus operator for enhancement of transport business management expertise and know-how.

For implementing the Short-term Plan to meet the projected bus passenger demand of 49,500 persons per day on 9 routes with 175 buses in 2005 (requiring the procurement of 100 additional buses), it is also recommended to seek various financial sources combined to include grant aid and loans from international and bilateral institutions. Table 22.9-6 shows the revenue and expense stream of the project which can lead to self-financing financial status and maintain the sustainability of the project, albeit as barely feasible, with a time span of 10 years. However, the bus operator shall be required to improve operational performance, in terms of bus availability ratio and seat occupancy rate by means of introduction of the management expertise and know-how as discussed in the following section.

Table 22.9-6 Revenue and Expense Stream of Immediate Action Plan and Short-term Plan

Unit: US$1,000

Year	Immediate Action Plan				Short-term Plan			
	Revenue	Expense	Balance	Acc. Bal	Revenue	Expense	Balance	Acc. Bal
2004	1,060	1,364	-304	-304	1,060	1,386	-326	-326
2005	1,535	1,364	171	-133	3,189	3,185	4	-322
2006	1,587	1,449	138	5	3,299	3,682	-383	-705
2007	1,642	1,541	101	106	3,412	3,900	-488	-1,193
2008	1,698	1,643	55	161	3,529	4,136	-607	-1,800
2009	1,757	1,790	-33	128	3,650	4,392	-742	-2,542
2010	2,596	1,954	642	770	5,393	4,670	723	-1,819
2011	2,674	2,071	603	1,373	5,555	4,913	642	-1,177
2012	2,754	2,198	556	1,929	5,722	5,173	549	-628
2013	2,837	2,460	377	2,306	5,894	5,894	0	-628
2014	2,922	2,840	82	2,388	6,599	6,532	67	-561
Total	23,062	20,674	2,388	-	47,302	47,863	-628	-
E/R rate				90 %				101%

(1) Implementing Agency

The project-implementing agency shall be the Department of Public Works and Transport (DPWT) of the Municipality of Phnom Penh (MPP). For the management of the Project up to completion of the bus procurement required for the Immediate Action Plan, a new project team, Bus Service Project Management Unit (BSPMU), should be organized in the DPWT. Also for supervision of the bus operation, the proposed Public Transport Management Unit (PTMU) in DPWT shall be newly established with the functions as described below and the detailed in Appendix 22.9.3.

The PTMU should be under supervision of the Deputy Director in charge of the Transport Office, DPWT which is to assume the following functions and responsibilities with the guidance of an expatriate consultant:

- To review applicable laws and regulations on bus transport services and related aspects, and to work out drafts of such regulations as necessary prior to commencement of the bus services;
  - Fixed-route bus transportation business (for fixed-route bus service with timetable),
  - Articles of association of the bus transporter (for business incorporation),
  - Articles of bus passenger transportation (on operator's obligations and rights to passengers),
    (Subjects listed below are not directly related to bus operation, but closely related and should be administered by the same unit.)
  - Chartered bus transportation business (for tourism purpose),
  - Taxi and chauffer-driven car transportation business (for urban taxi and hired taxi),
  - General cargo truck transportation business (for truck of either regular route or on-demand),
  - Mini-truck delivery business (for door-to-door delivery service),
- To monitor and evaluate all the management aspects of bus operators including the Transport Authority of Phnom Penh, and to advise, recommend and instruct those points that need improvement,
- To evaluate applications for bus tariff rates by both public and private sector operators, and approve them or advise revision, and
- To work out the manuals on management of bus operation and maintenance for distribution to the operators, with the purposes to improve and maintain the level of service, operational efficiency, and safety.

22.9.4 Conclusion

The project is evaluated as follows:

- Urgency:
  Very urgent to introduce an urban bus service as the most suitable mode of mass transportation system in Phnom Penh (see Section 22.6),
- Technical aspect:
  No difficulty anticipated in either procurement of vehicles or bus facilities installation (see Section 22.6),
- Economic aspect:
  Feasible on the condition that operation of the bus services are properly managed and maintained (see Section 22.8),
- Financial aspect:
  No problem on the condition that the project is extended grant aid by external source and operational efficiency is introduced by assignment of an expatriate consultant (see Sections 22.8 & 22.9),
- Institutional aspect:
  No problem expected on the condition that operational management is enhanced by assignment of an expatriate expert (see Section 22.9),
- Environmental aspect:
  No significant negative impact is expected (see Chapter 17).

The project is thus concluded to be urgent and feasible from all aspects with the successful introduction of the management know-how on bus transport operations. Therefore, it is highly recommended to implement the project as soon as possible. In order to maintain sustainability and self-financing of the Project operations, it is recommended that consultants be assigned to the implementing agency.

CHAPTER 23

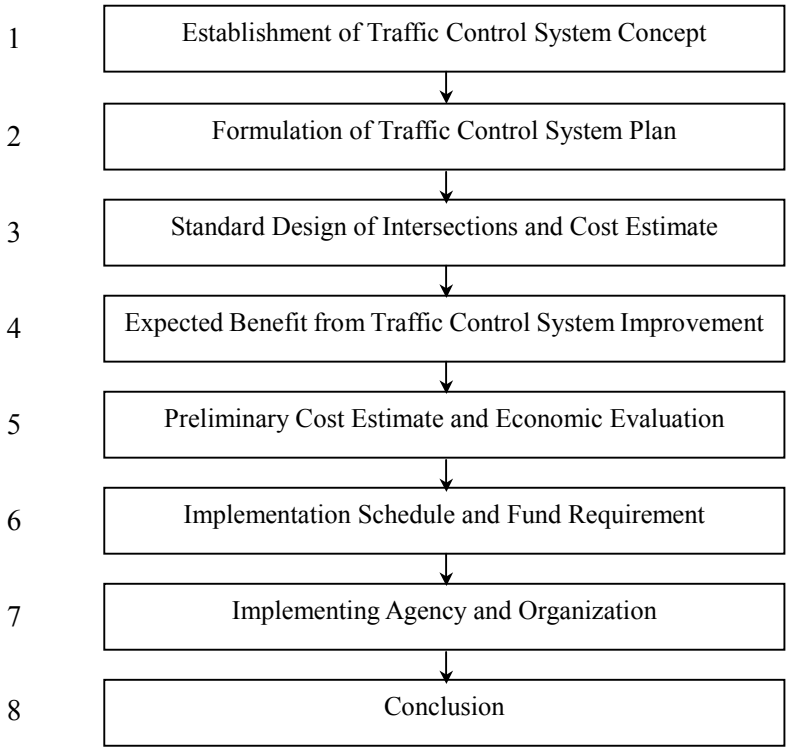
TRAFFIC CONTROL SYSTEM PLAN

CHAPTER 23

TRAFFIC CONTROL SYSTEM PLAN

This chapter describes the formulation of a traffic control system plan targeting at the major intersections from a traffic engineering perspective aimed at preventing or alleviating the deterioration of the traffic environment. Subsequently, the feasibility of this proposed plan is examined by means of an economic analysis.

The work procedure is shown in the following figure.



23.1 OBJECTIVES AND CONCEPT

The major objectives of this part of the Study are to improve the traffic flow and increase the traffic capacity at major intersections, and to reduce traffic accidents. With the proposed improvement measures, it becomes possible to implement more effective traffic safety programs and to further facilitate the enforcement against traffic violators. The provision of appropriate traffic facilities in Phnom Penh is an indispensable and basic necessity.

In this part of the Study, improvement to traffic flow in the urban areas is the first focus. Where appropriate and deemed necessary, such improvement measures are extended to the sub-urban areas. The approach adopted is therefore to improve the major arterial roads first. Subsequently, such improvements are to be extended to the collectors and local roads, with improvement to their surface pavement in addition. Emphasis is given to examining the form of improvement measures to be implemented at major intersections along the arterial roads, which have been found to be accident-prone and are frequently congested. Consequently, the features of appropriate improvements are examined and proposed in the study.

The prime intersection improvement measures are those that would facilitate smooth traffic flows such as geometric improvements, traffic control and operation improvements, as well as the installation of traffic signals as a means to strengthen the traffic control facilities.

The intersection improvement plan as proposed in this Study refers to the Stage1 Plan described in Section 15.3: "Traffic Signals". In addition, the plan calls for the replacement of the existing old traffic signal controllers with those having up-to-date functions. The project life span of the improvement plan is selected to be 15 years based on the common life period of traffic signals.

23.2 FORMULATION OF TRAFFIC CONTROL SYSTEM PLAN

(1) Identifying intersections that require signalization

Intersections that require signalization are identified based on the MPP signalization plan and the three basic criteria given below. Finally the intersections are selected though the discussions with DPWT officers / engineers and the Study Team.

(i) The functions of the intersecting streets

Priority in signalization of intersections is determined based on the functional type of intersecting streets in the following order:

- a major street intersecting with another major street,
- a major street intersecting with a collector street,
- other locations with specific cause of congestion such as intersections near markets along collector streets, which are already experiencing severe traffic congestion.

The following six (6) routes are the focus of the study as major arterial streets in the city:

- Monivong Blvd.
- Norodom Blvd.
- Kampuchea Krom Blvd.
- Charles De Gaulle Blvd.- Preah Monireth Blvd.
- Mao Tse Toung Blvd.
- Sihanouk Blvd.

(ii) On-site observations at intersections

- Road conditions

  Intersections with good road surface conditions or those which are scheduled to be improved in the near future.
- Traffic conditions

  Intersections with traffic congestion in peak hours at present

  Intersections with high possibility of traffic accidents

(iii) Traffic volume of the intersecting streets

The maximum hourly traffic volume from the minor street that can enter into the intersecting major street without affecting its flow while operating under its peak hour traffic volume (total of two directions) is first estimated using the equation below. Intersections whose future forecasted traffic volumes exceed this estimated value are deemed necessary to be signalized.

$$M = \frac{N e^{-NL}}{1 - e^{-NL}}$$

M : Maximum hourly volume from minor street (bigger volume from approach) without a signal control
N : Volume on main street (both ways in peak hour)
L : Vehicle headway on main street for safe operation of vehicles from the minor street

To apply the above equation, the traffic volume on the minor street has to be established. Given that data on such traffic volumes is not available, this traffic volume has to be estimated. In estimating the maximum hourly traffic volume from the minor street, the following assumptions/conditions are applied:

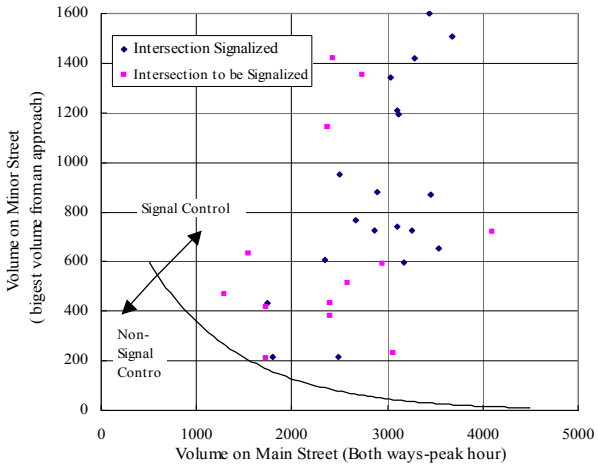
- Estimated traffic volumes from results of traffic assignment for year 2010 are used;

- A vehicle headway of 5 seconds is assumed for the safe operation of vehicles from the minor street, based on the fact that travel speed on the urban streets is found to be about 40-50 kph.
- Mathematical formula obtained from computer simulations by KELLY and others are used to calculate the threshold number of vehicles entering the intersection from the minor street.

The result of the estimation described above is illustrated in Figure 23.2-1.

The intersections that are identified for signalization, based on the above criteria as well as the discussions with DPWT officers and engineers, are described below:

- A total of 33 signalized intersections:
  - 21 existing signalized intersections,
  - 12 additional intersections in Stage 1 (see Section 16.2).
- Route system signal control to be provided on six (6) major arterial routes,
  - Monivong Blvd.
  - Norodom Blvd.
  - Kampuchea Krom Blvd.
  - Charles De Gaulle Blvd. Preah Monireth Blvd.
  - Mao Tse Toung Blvd.
  - Sihanouk Blvd.
- Signalization and Improvement of roundabouts:
  (Removal of roundabout and signalizing the cross junction)
  - Roundabout of S. Monired Blvd. / Mao Tse Toung Blvd.
  - Roundabout of C. de Gaulle Blvd. - S. Monireth Blvd./Neruk Blvd.-Sihanouk Blvd. (Retaining the roundabout and signalizing the approaches)
  - Roundabout of Monivong Blvd. – NR No. 1 /. Norodom Blvd –NR No. 2



* Equation of the curve is given in 23.2 (1) (iii)

Figure 23.2-1 Traffic Volume at Intersection to be Signalized

The locations of the 33 intersections for signal improvement/installation are listed in Table 23.2-1 and shown in Figure 23.2-2.

(2) Required Basic Functions at the Proposed Signalized Intersections and Relevant Measures

The following measures should be implemented together with the improvement of signals:

- Introduce vehicle channelization facilities in order to facilitate segregation of vehicle types as well as to guide the orderly flow of vehicles,
- Install exclusive left turn lane and left turn signals,
- Install traffic signals with higher function
- Install traffic signs and pavement markings to encourage observance of traffic rules by drivers and pedestrians.

The following functions are required for the proposed signal control:

- Adjusting signal timings in response to the fluctuations of traffic demand in order to increase intersection capacity,
- Display exclusive left-turn signal in order to increase intersection capacity,
- Coordinating or synchronizing function for progressive signal control between adjacent intersections in order to increase route capacity, especially at locations with short distance between adjacent intersections,

Table 23.2-1 List of Intersections for Improvement/Installation the Study

	Name of Intersections	Road Function	No. of Legs	Existing Signal Control	Volume (1000 Veh./Day)	Type of Intersection (see Sec. 23.3)
1	Monivong Blvd /Preah Ang Doung / Russia Blvd	Major - Major	4	Signal	64.5	1
2	Monivong Blvd /Kampuchea Krom Blvd	Major - Major	4	Signal	76.5	1
3	Monivong Blvd /Charles de Gaulle Blvd	Major - Major	4	Signal	76.8	1
4	Monivong Blvd /Rue Tep Phan (St.182)	Major-Collector	4	Signal	65.3	2
5	Monivong Blvd /Rue Samdech Panh (St.214)	Major-Collector	4	Signal	59.9	2
6	Monivong Blvd /Sihanouk Blvd	Major - Major	4	Signal	85.0	1
7	Monivong Blvd /St.310	Major-Collector	4	No Signal	50.2	3
8	Monivong Blvd /Mao Tse Tong Blvd	Major - Major	4	Signal	79.4	1
9	Monivong Blvd – RN1 /Norodom Blvd – RN 2	Major - Major	R'about	No Signal	70.9	3
10	Norodom Blvd /Preah Ang Doung (St.110)	Major - Major	4	Signal	61.3	1
11	Norodom Blvd /St.130	Near Market	4	Signal	36.2	2
12	Norodom Blvd /Rue Decho Dam Din (St.154)	Major-Collector	4	Signal	40.9	2
13	Norodom Blvd /Rue Samdech Panh (St.214)	Major-Collector	4	No Signal	39.8	3
14	Norodom Blvd /Mao Tse Tong Blvd	Major - Major	4	Signal	59.5	1
15	Russia Blvd /Mao Tse Tong Blvd	Major - Major	4	Signal	108.8	1
16	Russia Blvd /Kampuchea Krom Blvd /St.271 /598	Major - Major	5	No Signal	64.6	3
17	Kampuchea Krom Blvd /St.109	Major-Collector	4	No Signal	53.9	3
18	Kampuchea Krom Blvd /Rue Batuk (St.169)	Major-Collector	4	Signal	72.1	2
19	Kampuchea Krom Blvd /Nerhu Blvd (St.215)	Major - Major	4	Signal	92.2	1
20	Kampuchea Krom Blvd /Mao Tse Tong Blvd	Major - Major	4	Signal	93.0	1
21	Charles de Gaulle Blvd /St.109	Major-Collector	4	No Signal	44.0	3
22	Charles de Gaulle Blvd /Sihanouk Blvd	Major - Major	R'about	No Signal	75.7	3
23	St.182 /St.161	(Near Market)	4	Signal	39.1	2
24	Monireth Blvd /Mao Tse Tong Blvd	Major - Major	R'about	No Signal	73.1	3
25	Nerhu Blvd /Rue Tep Phan (St.182)	Major-Collector	4	Signal	58.4	2
26	Sihanouk Blvd /St.199	(Near Market)	4	No Signal	56.2	3
27	Sihanouk Blvd /St.161	Major-Collector	4	Signal	63.7	2
28	Sihanouk Blvd /Rue Trasak Paem (St.63)	Major-Collector	4	Signal	40.5	2
29	Sihanouk Blvd /Samdech Sothearos Blvd	Major-Collector	4	No Signal	67.0	3
30	Mao Tse Toung Blvd /Rue Tep Phan (St.182)	Major-Collector	4	Signal	60.6	2
31	Mao Tse Toung Blvd /St.163	Major-Collector	4	Signal	67.3	2
32	Mao Tse Toung Blvd /St.336	(Near Market)	4	No Signal	57.5	3
33	Mao Tse Toung Blvd /Rue Trasak Paem (St.63)	Major-Collector	4	No Signal	67.8	3

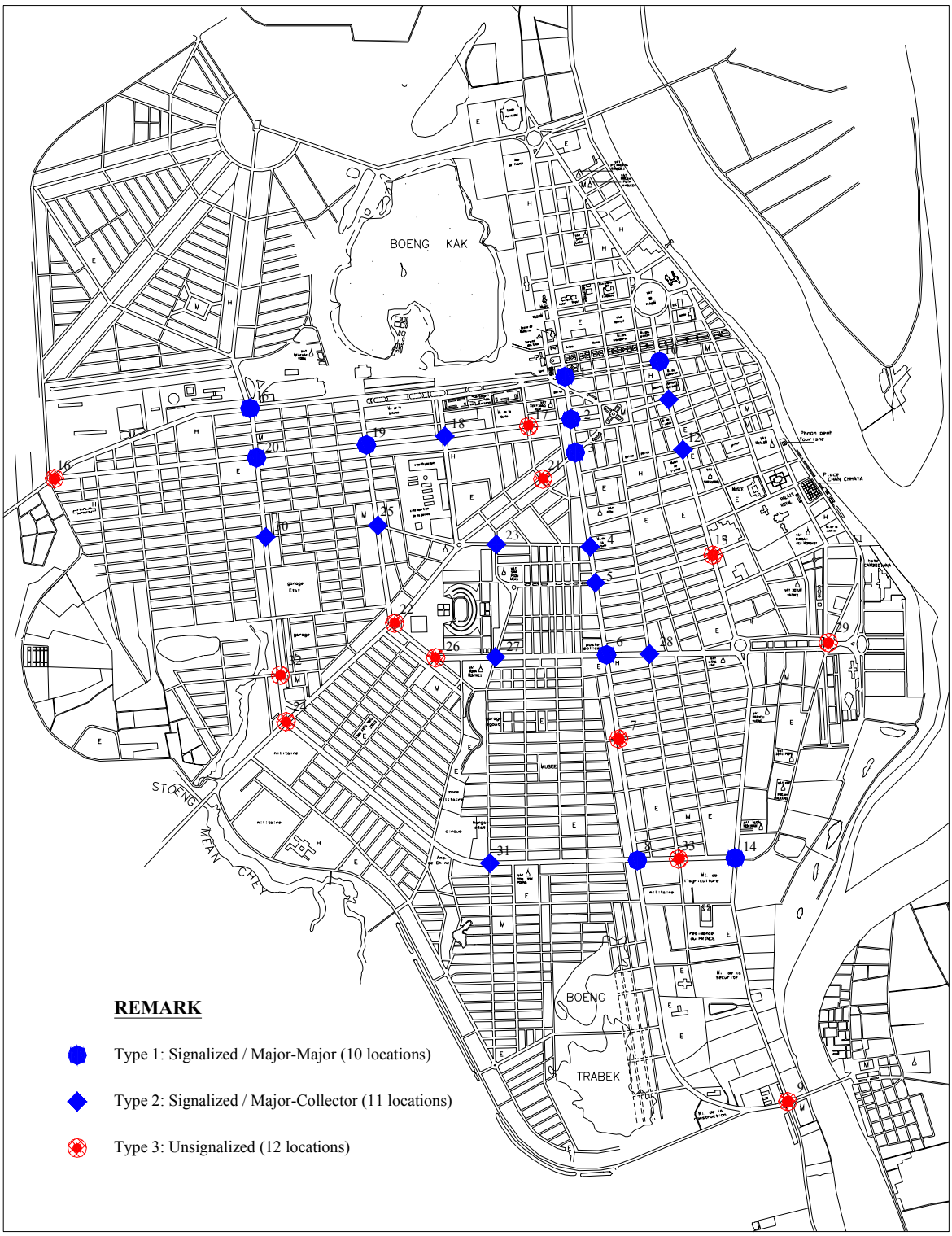


Figure 23.2-2 Intersections to be signalized in the Stage I
(The number of Intersections corresponds to the number in Table 23.2-1)

- Display phase exclusively for pedestrian in order to protect pedestrians,
- All red signal display function in order to clear vehicles in the intersection after yellow signal display and to protect pedestrians,
- Automatic switching to a fixed parameter signal control mode during equipment failure in order to prevent confusing signal displays,
- A manual control function to be used in emergency .
- Emergency power supply to cope with power failure.

With the above improvements, a smoother traffic flow at the intersections is expected, owing to improved traffic capacity, while the traffic safety level is upgraded.

23.3 STANDARD DESIGN AND CONTROL OPERATION AT INTERSECTIONS

Typical intersections representing various types are selected so as to develop standard intersection improvement designs by types, for improving traffic operation at all intersections. The traffic volumes observed in June of 2001 are used in the design.

The three typical intersections selected for this purpose are described below together with their major improvement measures

(1) Kampuchea Krom Blvd. / Mao Tse Toung Blvd.
This intersection is a typical signalized 4-legged intersection of a four lanes divided major street intersecting with another similar major street (Type 1).

The major improvement measures proposed for such intersections are:
- installation of exclusive left-turn lane and signal in order to segregate left turning vehicles,
- channelization of vehicles through the use of suitable markings or installation of a median, (for markings, durable thermal plastic materials should be used)
- provision of lane markings to channelize traffic streams and pedestrian traffic, and to prohibit roadside parking and others. (Figure 23.3-1(1))

(2) Mao Tse Toung Blvd. / St.163
This intersection represents a typical signalized 4-legged intersection of a major street with a collector street. The major street is a four lanes divided road while the collector is a two lane undivided street (Type 2).

The major improvement measures proposed for this intersection are:
- Measures similar to those for the above major road intersection,
- Widening of approach sections on the minor street to accommodate exclusive left turn lanes. (Figure 23.3-1(2))

(3) Sihnouk Blvd. / St 199/ St.264
This is a non-signalized, irregular, 4-legged intersection of a major street with two collector streets (Type 3). Severe traffic congestion occurs regularly during peak hours and it is also a hazardous intersection.

The major improvement measures proposed for this intersection are:
- Regulate one of the collector approaches as a one-way operation, whereby traffic is prohibited from entering the intersection. Signalization is proposed to control the traffic on the remaining approaches forming a T junction,
- Provide an exclusive left-turn lane on one of the approaches on the major street, and an exclusive right-turn lane on the opposite approach.
- Provide pavement markings to channelize traffic streams, pedestrian traffic and to prohibit road side parking and others. (Figure 23.3-1(3))

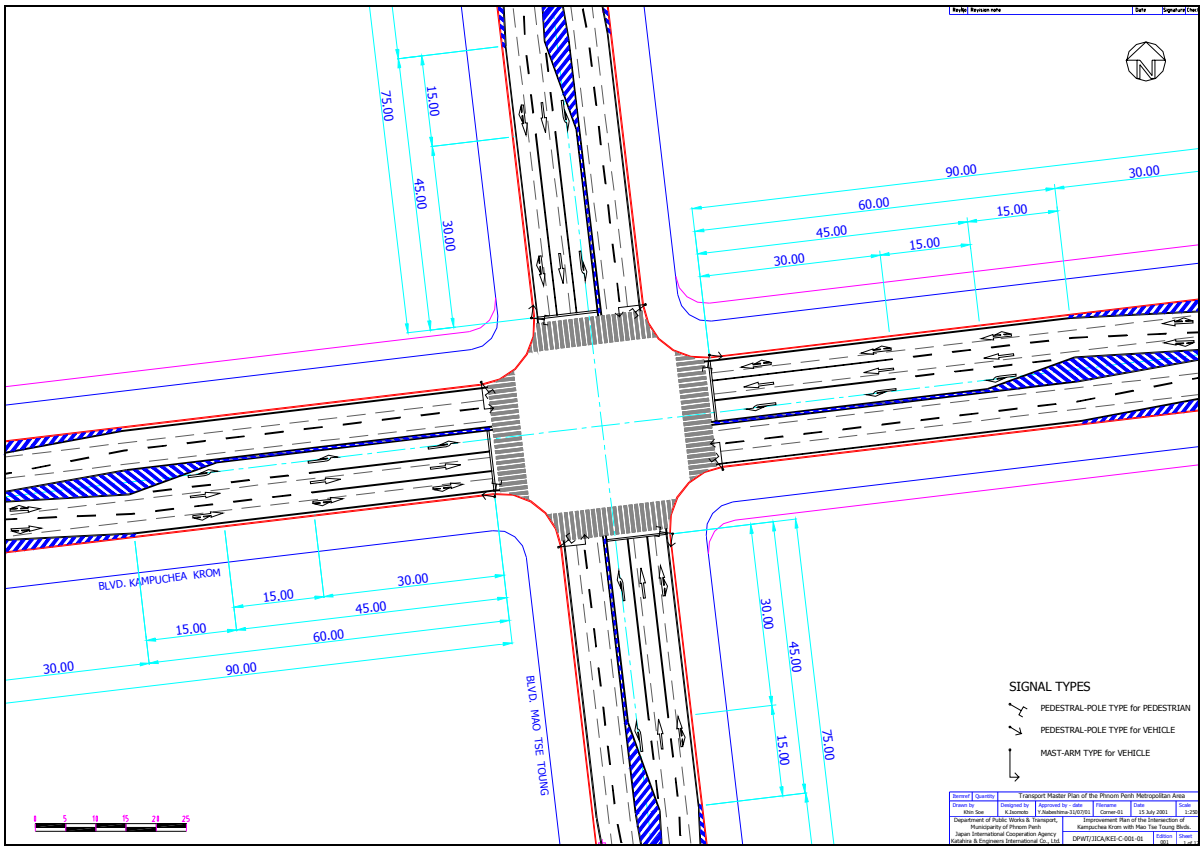


Figure 23.3-1(1): Standard Design at Kampuchea Krom Blvd. / Mao Tse Toung Blvd.

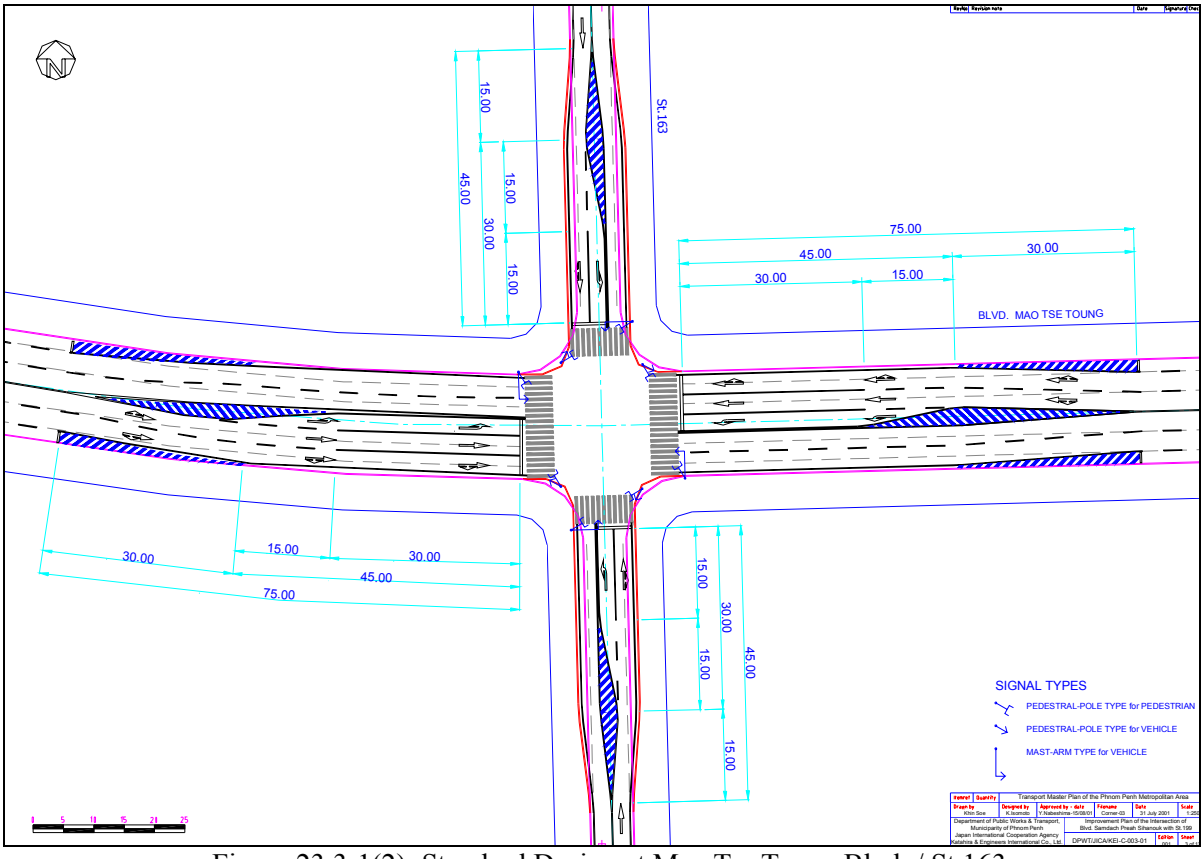


Figure 23.3-1(2): Standard Design at Mao Tse Toung Blvd. / St.163

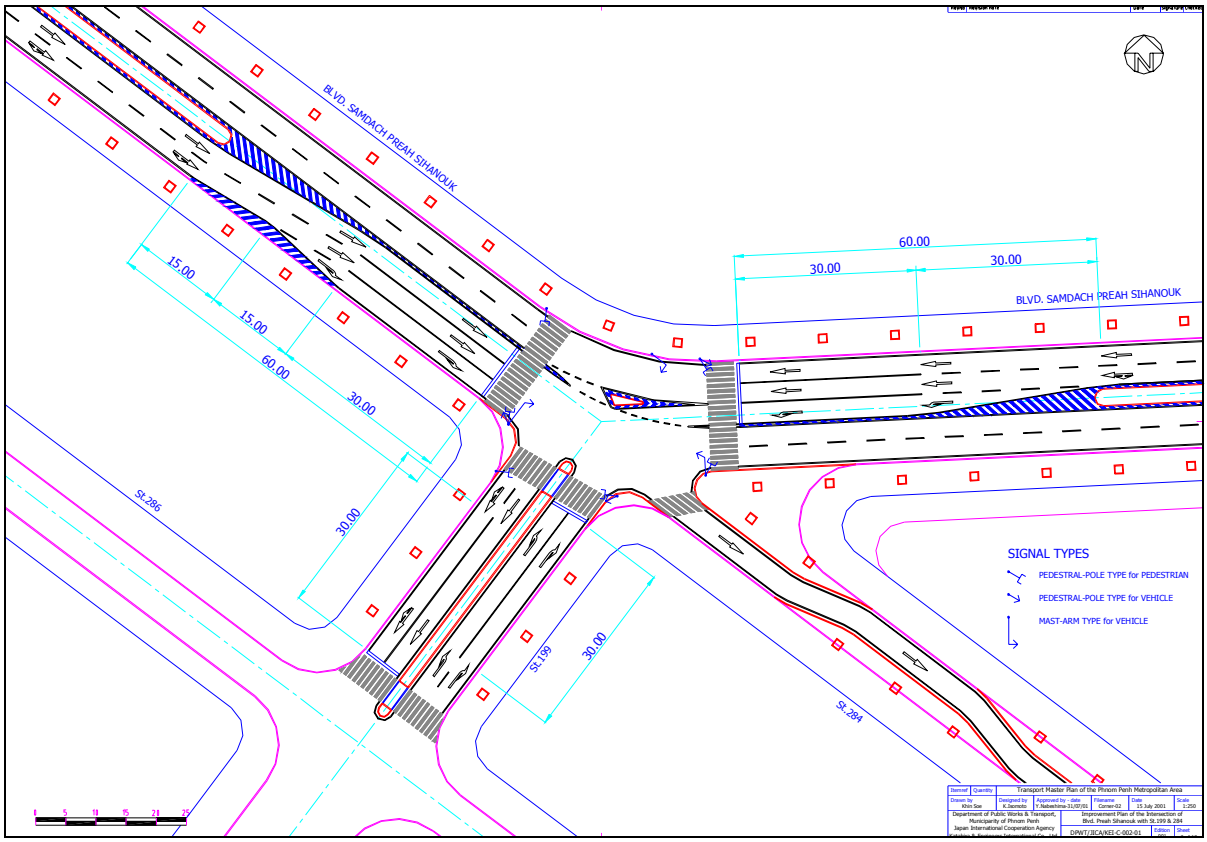


Figure 23.3-1(3): Standard Design at Sihanouk Blvd. / St.199 / St.284

23.4 EXPECTED BENEFITS

(1) Types of Benefits

The improvements can bring about an increase in overall travel speed and traffic capacity by promoting orderly and smooth traffic flow and thereby reducing travel time. As a consequence, there will be a saving in fuel consumption and other vehicle operation costs (VOC). There would also be a reduction in traffic accidents. From the environmental point of view, such improvements would also yield reduction in emission of pollutants such as CO, CO2, NO and NOx, and a reduction in the level of noise and vibration.

The quantifiable benefits (time cost savings and savings in fuel consumption) are used in the economic analysis as described in Section. 23.5.

Changes in Travel Time and Speed due to Traffic Control and Signal Improvements

(i) Estimation Method and Results

- A simulation model called "TRAF-SETSIM" developed by US Department of Transportation (DOT) was used to estimate average travel time and average travel speed of various vehicle types for "present situation" and "after improvement". Hourly traffic volumes were estimated for the three (3) intersections described in Section 23.3. In this simulation, traffic volume is converted to PCU. (Motorcycle=0.25 PCU, Heavy truck = 3 PCU)
- The increase in future traffic volume is estimated for year 2005, 2010 and 2015, using a growth rate estimated by the 'Traffic Demand Forecast' described in Part 2.
- The hourly travel time and fuel savings are then estimated using the hourly distribution

pattern of daily traffic volume (see Figure 23.4-2). These are then converted to the total daily savings in travel time and fuel. (see Table 23.4-1) The saving in fuel consumption is computed using correlation data between travel speed and fuel consumption rate as given in the Report of the Study on Urban Transportation Planning of Damascus City, JICA 1999.

Table 23.4-1: Estimated Total Daily Savings in Travel Times and Fuel for 2000 -2015

Location	Year	PCU in 14 hr's	Delay (hrs/14 hr's)			Fuel Consumption (liters/14hr's)		
			Without	With	Difference	Without	With	Difference
Kampuchea Krom / Mao Tse Toung	2000	56,945	521	352	169	1,480	1,437	44
	2005	59,436	612	393	219	1,563	1,508	56
	2010	62,036	744	447	297	1,657	1,585	72
	2015	64,749	925	513	412	1,764	1,669	95
Mao Tse Toung / St. 163	2000	54,034	696	419	276	1,442	1,371	72
	2005	56,398	848	506	343	1,533	1,446	87
	2010	58,865	1,020	609	411	1,629	1,530	99
	2015	60,890	1,163	699	464	1,725	1,620	105
Sihanouk / St. 199 / St. 264	2000	46,824	787	432	355	1,285	1,177	108
	2005	48,870	866	463	403	1,349	1,230	119
	2010	51,010	950	498	451	1,417	1,286	131
	2015	53,243	1,038	538	501	1,487	1,345	142

Note: Delay is expressed in PCU, while fuel consumption is total savings computed based on different vehicle types.

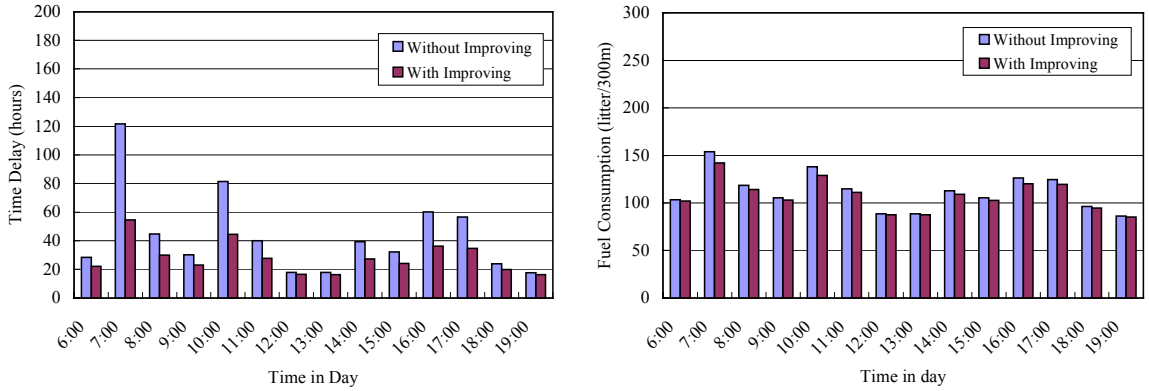
(ii) Examination of the Results

The first two intersections in the Table 23.4-1 are presently signalized intersections. It is clearly seen that savings in both travel time and fuel consumption can be achieved through improvements on these intersections. The huge differences in delay in particular are mainly due to the fact that the cycle time and split time of the existing signals are fixed at 50% and 50% and, thus the signals are unable to adapt to the changing traffic demand.

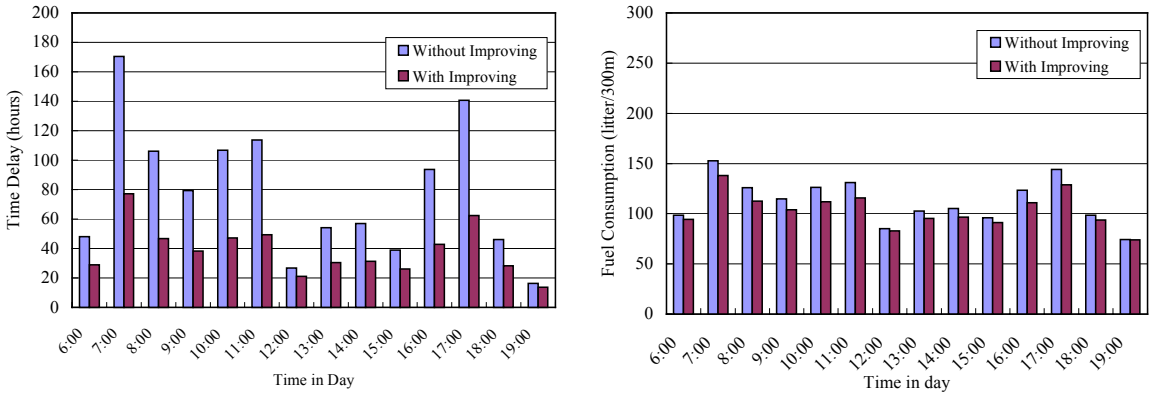
The intersection of Kampuchea Krom Blvd / Mao Tse Toung Blvd is a typical intersection of two major streets, both of which are 4-lanes divided roads. All the approaches to the intersection feature two (2) lanes in each direction. Furthermore, traffic volumes on both intersecting streets are about the same. Thus, compared to the second intersection of Mao Tse Toung/St. 163, this particular intersection is functioning relatively well.

Conversely, approaches to the second intersection of Mao Tse Toung Blvd /St.163 are different in width and lanes, and, therefore, differ in traffic demand. Consequently, the signal with fixed split time of 50% - 50% cannot function efficiently. Hence the delay without improvement in this intersection is much greater than the first intersection.

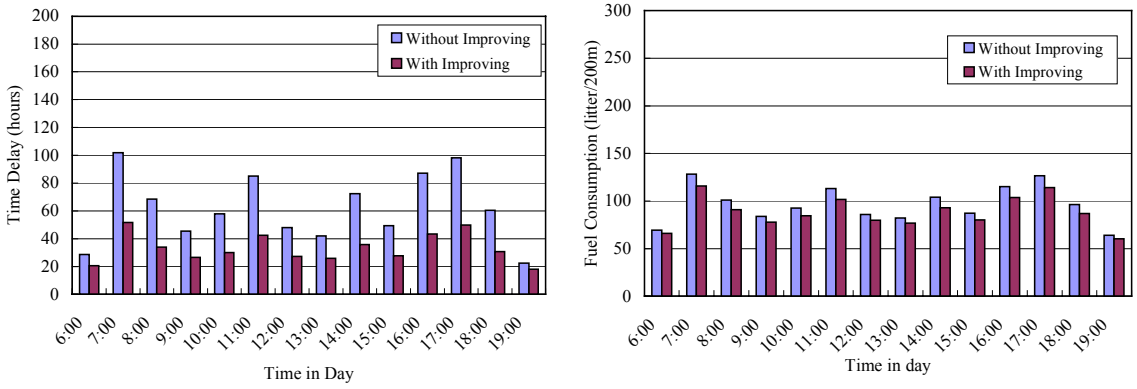
The third intersection of Sihanouk Blvd./St 199 /St 264 is currently not signalized. Hence when traffic demand increases in the future, travel time is predicted to increase drastically. If no improvements are made under this condition, it becomes almost impossible for traffic from the minor street to enter the intersection. Any attempt to do so will inevitably create traffic-jam at all other approaches. After improvements are made (one collector street is designated as one-way) the intersection will basically function as a T- shape intersection instead of an irregular 4-legged intersection and hence delays will be reduced significantly.



Time Delay and Fuel Comsuption at Mao Tse Toung Blvd./ Kampuchea Krom Blvd.



Time Delay and Fuel Comsuption at Mao Tse Toung Blvd./ St 163



Time Delay and Fuel Comsuption at Sihanouk Blvd./ St 199

Figure 23.4-2 Hourly Fluctuation of Delays Time and Fuel Consumption at 2005

23.5 PRELIMINARY COST ESTIMATE AND ECONOMIC ANALYSIS

(1) Preliminary Cost Estimate

Table 23.5-1 shows total costs estimated for the implementation of traffic control system at the proposed 33 intersections in Stage 1. The table indicates that the project requires a total of US$2.8 million.

Traffic signal equipment and traffic control facilities such as pavement markings and traffic signs are assumed to be imported. Local labor is assumed for installing the equipment and devices.

Table 23.5-1 Estimated Cost of Traffic Control System (2001~2005)

In US$

Items	Unit	Unit Cost	Quantity	Amount
1.Intersection Improvement				
Signal Equipment and Installation	Intersection	61,000	33	2,013,000
UPS Equipment and Installation	Intersection	4,000	5	20,000
Traffic Control Devices	Intersection	5,000	33	165,000
Geometric Improvement	Intersection	3,000	33	99,000
Geometric Surveys and Signal Timing Plan	Intersection	1,200	33	39,600
2.Engineering Cost				
Foreign Consultant	Man-Month	15	26,000	390,000
Local Consultant and Office Management	Lump Sum	55,400	1	55,400
Total				2,782,000

(2) Economic Analysis

(i) Procedure of Analysis and Assumptions

To estimate the economic benefits accrued from the improvement, the reduction of traffic congestion due to the improvement needs to be estimated using the simulation model described in Sub-section 23.4 (1) (i). Considerable time is required to apply this simulation on all of the 33 intersections which are proposed for improvement. In addition, traffic volumes on the minor roads of these intersection needs to be estimated in the traffic demand forecast as described in Part II. (Actual traffic volumes on minor roads have not been surveyed.) Considering the time frame of the Study and accuracy of available data, the economic benefits of the improving the 33 intersections are estimated with the procedures as descried below:

i) 33 intersections are classified into three (3) types as shown in Table 23.2-1.
ii) At three (3) typical interchanges, the said simulation was conducted for various traffic volumes, and the relations between traffic volume and average delay time were obtained for three (3) intersections.
iii) Average delay time of an intersection was estimated by inputting the traffic volume of the said intersection to the relation between the traffic volume and delay time obtained for the typical intersection corresponding the said intersection through the procedure described in ii) above.
iv) Average delay time thus obtained is multiplied by the traffic volume of the said intersection and the total delay time is obtained.
v) Economic benefits thus obtained for individual intersections were summed up for the all 33 intersections.

The above procedure is considered to yield the estimation with an acceptable accuracy. This procedure is adopted considering the time constraints and required accuracy.

The economic analysis for the 33 intersections were carried out under the following basic assumption:

- Project life for improvement of intersections is taken as 15 years based on the common design life of signals.
- Economic cost is composed of costs of traffic signal control system, geometric improvement, engineering cost and operating cost.
- Quantified benefits include the reduction in delay time and saving in fuel consumption.
- The discount rate is at 12% p.a.

(ii) Economic Cost

Economic costs of signals and other equipment are calculated by deducting tax from the financial costs as shown in Table 23.5-2.

Table 23.5-2 Estimated Economic Costs of Improvement of Three Typical Intersections

In US$

Item	Mao T.T.	Mao T.T./ St.163	Sihnouk/St.199
Intersection Improvement Cost	72,700	71,700	74,200
Engineering Cost & Office Management	13,500	13,500	13,500
Total	86,200	85,200	83,700
Note: Equipment and software are assumed to be exempted from taxes.			
Operating Cost (per year)	850	850	850

(iii) Quantified Benefit

Unit traffic costs of delay time and fuel economic cost are shown in Table 23.5-3. These costs are quoted from Table 13.2-15 and Table 13.2-11, respectively. Estimated total benefit is shown in Table 23.5-4.

Table 23.5-3 Delay Time Cost and Fuel Cost In US$

	Passenger Car	Motorcycle	Heavy Vehicle
Delay Time Cost	0.25/hr	0.09/hr	-
Fuel Cost	(Regular) 0.36/litre	(Regular) 0.36/litre	(Diesel) 0.31/liter

Table 23.5-4 Estimated Total Benefits in US$ 1,000/year

Intersection	Traffic Volume (Daily)				W/O		With		Benefit
	P. Car	M'cycle	H.Veh	Total	Delay	Fuel	Delay	Fuel	
2005	687,100	3,893,300	26,700	4,607,100	2,430	6,065	1,486	5,766	1,243
2010	717,400	4,062,200	27,900	4,807,500	2,817	6,399	1,670	6,051	1,494
2015	749,600	4,244,600	29,200	5,023,400	3,332	6,774	1,922	6,377	1,808

Note: Saving of fuel cost is much bigger than saving of delay time cost due to lower unit cost of delay time.

(iv) Economic Indicators

Economic analysis was conducted for the all proposed 33 intersections. The results showed very high values of the EIRR, B/C and NPV. This indicates that improvements to the traffic control system at these locations would produce substantial benefits.

Table 23.5-5 Economic Indicators

Intersection	EIRR (%)	B/C	NPV (US$)
33 proposed intersections	44.9	3.4	6,500,000

(v) Sensitivity analysis

The sensitivity analysis was made for the following factors:

- Changes in estimated project cost
- Changes in the estimated traffic volume entering to the intersections

Increase and decrease of 15% in both factors were applied to the analysis.

Table 23.5-6 shows the changes in EIRR and B/C due to the changes in estimated traffic volume and project cost. It is seen from the results that both EIRR and B/C are more sensitive to the change in intersection traffic volume than to that in the project cost.

Table 23.5-6 Changes in EIRR and B/C due to Volume and Cost Changes

		Item	Traffic Volume Entering to Intersection		
			-15%	Original	+15%
Estimated Cost	-15%	EIRR (%)	22.7	52.2	82.3
		B/C	1.8	4.0	6.4
	Original	EIRR (%)	19.3	44.9	70.8
		B/C	1.5	3.4	5.4
	+15%	EIRR (%)	16.7	39.4	62.2
		B/C	1.3	3.0	4.7

23.6 IMPLEMENTATION SCHEDULE AND FINANCING

(1) Implementation Schedule

After sufficient funding is secured for the Project, it will take about 18 months before the system is operated. Assuming that the proposed Project start in year 2003, its operation will start in the middle of 2004. Table 23.6-1 shows the implementation schedule of the Project.

Table 23.6-1 Time Schedule of Main Tasks in Project Implementation

Main Activity	2002				2003				2004				2005			
	3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
commence of Project					●											
bidding of consultant					■											
engineering design						■	■									
bidding of contractor							■	■								
installation and testing								■	■	■						
operation of system											■	■	■	■	■	■

(2) Financing

The proposed Project should ideally be financed from the Municipality's own fund source and/or subsidy from the Central Government of Cambodia. Although the Project does not generate any financial income from the beneficiaries the Project is a necessity for the overall road traffic system in promoting traffic safety and better traffic environment in the capital city of Cambodia, and would help promote economic growth and better social well-being for all citizens in the city.

If the Municipality does not have sufficient funds, the Municipality may have to seek other viable fund resources. One of the possible candidates of such fund source is Official Development Assistance (ODA) from donor agencies. However, continuous assistance to fully implement the proposed system may not necessarily be expected. For this reason, an alternative source of revenue should be sought.

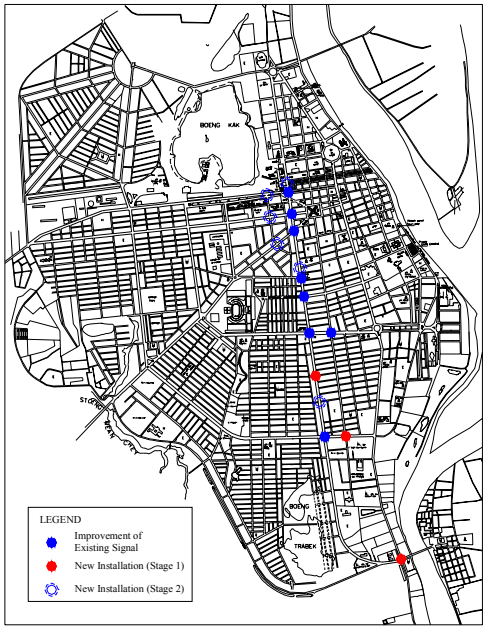


Figure 23.6-1 Improvement of Traffic Signal System along Monivong Blvd

Urgent Plan

Considering the urgency of the Project and severe financial constraints, further staging of the Project implementation may be necessary in reality. One method is to install signals at presently unsignalized intersections as the first step, and improvement of the existing signals is implemented in the second step. Another method is to improve/install signals along important street, such as Monivong Blvd, as shown in Figure 23.6-1. While the former is expected to yield better economic benefits, the latter is more suitable as the "pilot case" to examine the combined effect of the new signals.

23.7 IMPLEMENTATION AGENCY AND ORGANIZATION

(1) Implementing Agency

The Department of Public Works and Transport in the Municipality of Phnom Penh, supported by the Ministry of Public Works and Transport, and the Municipality Traffic Police should jointly undertake the implementation of the project.

(2) Organization

A traffic management division district from the road construction division in DPWT, MPP should be established to directly oversee the overall traffic management operations in order to maintain safe traffic flows and ensure smooth and comfortable travel.

The main tasks of the division are to formulate plans on traffic engineering improvements as well as traffic safety enhancement, implement these plans and evaluate their performances. The division will also have to continuously install and maintain various traffic control facilities, especially traffic signals, as the city grows and the road network expands. Six (6) traffic engineers shall be required as the staff to carry out these tasks.

A suggested organization chart is shown in Figure 23.7-1.

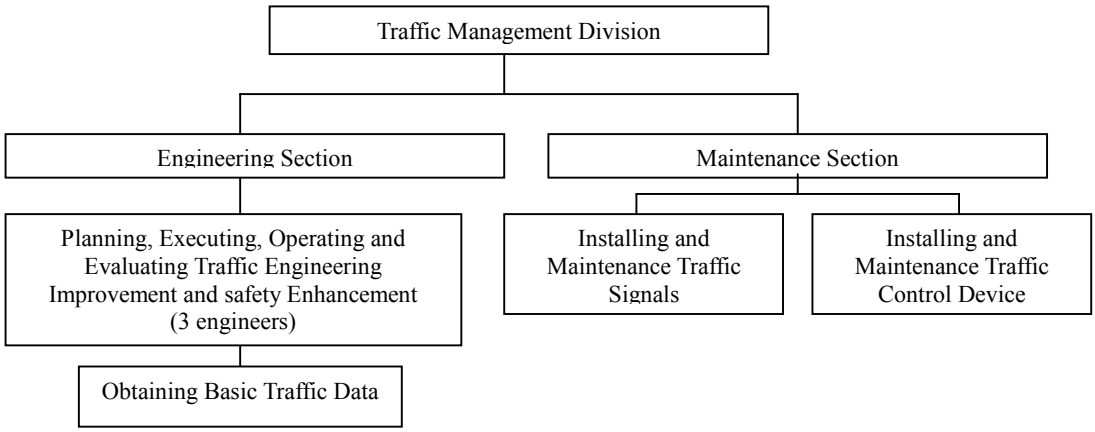


Figure 23.7-1 Organization Chart of the Suggested Traffic Management Division

23.8 CONCLUSIONS

The Project is proposed, from the traffic engineering point of view, to apply various improvement measures to 33 selected intersections including the existing signalized intersections along major arterial streets.

The following are the main proposed improvement measures:
- Signalization of the intersections with such functions as coordinated control, time-of-day control and exclusive left-turn signal phase,
- Providing adequate pavement markings and signs

It is found from the economic analysis that benefit of the Project is substantial.

Thus, it is concluded that the Project is urgent and feasible, and should be implemented as soon as possible. Moreover the implementation cost is much lower and the construction period is shorter than new construction or improvements of roads. In addition, the proposed improvement measures have been shown in this Study not only to increase the traffic capacity at these intersections, but also to enhance the traffic safety level in the city effectively and quickly.