2.2.3 Traffic Signal Control Improvement

In this section, firstly, common methods of traffic signal control is described. Secondly, an appropriate signal improvement method under the present traffic condition in Phnom Penh City and efforts to upgrade the signal control system in the future are discussed.

(1) Outline of Traffic Signal Control

Methods of traffic signal control is divided broadly into 2 categories from the following perspectives:

- Category based on area signal control perspective:
  - Isolated signal control
  - Progressive signal control
  - Area signal control
- Category based on the alternative methods in defining a control parameter
  - Fixed time control
  - Time- of -day control
  - Actuated control
  - Responsive control

In addition, there are special signal control methods such as exclusive bus signal control and others.

Table2.2.4 shows each of these categories and their respective contents of signal control methods.

Table2.2.4: Category of Traffic Signal Control

Perspectives	Category and contents of control	
Extent of signal control	Isolated signal control	Isolated signal control at single intersection.
	Progressive signal control	Coordinated control of a series of intersections along one route.
	Area signal control	Integrated control of signalized intersections in an urban area with a centralized control system.
Method in defining the control parameter	Fixed time control	Repeated signal indications following an established control pattern.
	Time- of -day control	Prepared some control patterns depending on day and time. The best control pattern is chosen automatically by a perpetual calendar.
	Actuated control	The parameter is decided based on real time information provided by vehicle detectors equipped at inflow point of intersection. The signal is controlled by such a parameter.
	Traffic Responsive Control	Controlled by an appropriate parameter, which is decided by a computer based on information from vehicle detectors equipped at many points in the urban areas.
Special signal	Pedestrian push-button signal, exclusive bus signal, etc.	

(2) Existing Signalized Intersections and Signal Operation

There are presently 20 signalized intersections in the CBD area defined by the ring road of Blvd.Mao Tse Tong.

The following 5 came under observations on the existing signal operation:

- Signal control deploys the same fixed signal control with the simple 2-phases, together with the pedestrian signals. The 3 or 4-phase signal controls to accommodate left and right turning vehicles cannot be handled by the existing signal controllers.
- Signal cycle, split times and other signal parameters are all fixed. Therefore signal control that can response to varying traffic demand cannot be executed.

- The existing signal controller is not capable of synchronizing or coordinating signals at one intersection with those of the adjoining signalized intersection. For this reason, all the signalized intersections work as stand-alone type of signal control. When the distance between two signalized intersections is too short, the signal control becomes ineffective and congestion is common.
- The timings for the pedestrian signals coincide with those for the vehicle signals. In other words, when the signal for vehicles turns green, so is the pedestrian signal. When the vehicle signal turns from green to yellow, the pedestrian signal changes from green to red. In general, the green times for the vehicle signals and pedestrian signals should be different.
- Signal control using blinking red and yellow displays can not be operated during midnight.

(3) Traffic Signal Operation in the Short Term

1) Minimum functions required on local controller
It is not necessary to introduce a high level signal system within the next 5 years, but the existing signal local controllers should be replaced by a new type of local controllers with minimum functions required, and such new controllers must be applied to all new intersections that are due to be signalized .

The following functions should be at least required for the new controllers:
- Time-of-day signal control (with a minimum of 3 patterns in a week and 5 patterns in a day)
- Number of signal phases (at least, phases for through vehicles, left-turning vehicles, exclusive pedestrian signal, blinking red and yellow lights etc.)
- Coordinated function for progressive signal control between adjacent intersections
- Function of operation by emergency signal timing during malfunction

2) All red signal display
It is proposed that an all red signal display after the yellow signal be introduced for achieving total clearance of vehicles and pedestrians within the intersection.

3) Location of overhead signal heads
It is preferable to re-consider the installation standard of traffic control devices at an intersection such as location of overhead signal heads, location of pedestrian crossings and stop lines markings.

The main problems currently faced in Phnom Penh are as follows:
i) Due to the long distance between the drivers' eyes and the signal head, the lost time of efficient green, clearance time and passing time through the intersection are so long that the maximum handling capability at the approach is reduced.
ii) Due to the long distance between the stop line to the corner, there is a high possibility that vehicles stop over the stop line, and violates the traffic rule.
iii) Walking distance when crossing the road becomes too long for pedestrian to walk on the crosswalk.

It is proposed that these signal devices be installed closer to the corner of the intersection to cope with such problems, as shown in Figure 2.2.6.
Another benefit of such a proposal is to save the straight pole for the pedestrian signal head and a vertical vehicle signal head on an exit leg of intersection, by means of installing them on the arm type pole.

4) Location of pedestal signal heads
It is also preferable to re-consider locations of pedestal signal head without combination with overhead signal heads along a collector road. It is necessary to install it not only at the near side of an intersection, but the far side.

5) Intersections necessary to be signalized
Based on site observations, intersection analyses using actual traffic data and intersection improvement plan by MPP, it is necessary to signalize immediately the following 13 intersections, shown in Figure 2.2.7.
Urgent priority of signalization
i) Intersection of Blvd. Mao Tse Tong / Rue.336
ii) Intersection of Blvd. Charles De Gaulle / Rue.109

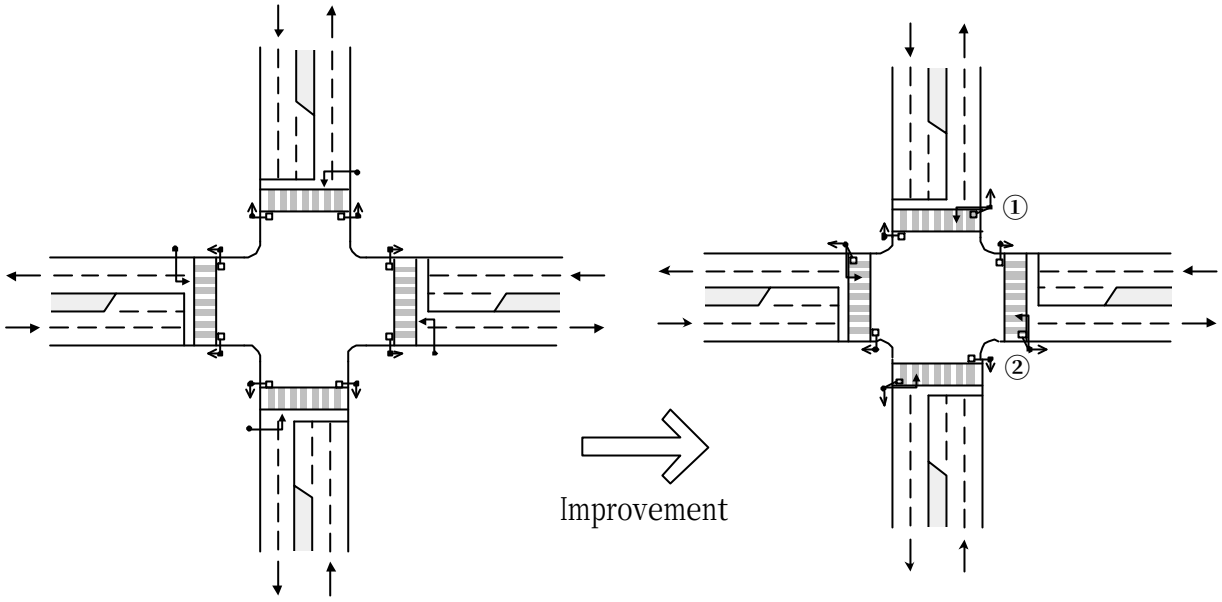

Figure 2.2.6: Improvement on the locations of traffic control devices such as overhead signal poles, crosswalks and stop lines

iii) Intersection of Rue Tep Phan(182) / Rue 161
iv) Intersection of Blvd. Preah Sothiros / Blvd. S. P. Sihanouk
v) Intersection of S.P.Sihanuk /Rue.199 /Rue 284
vi) Intersection (roundabout) of Blvd. Mao Tse Tong / Blvd. Preah Monireth
It is necessary to remove the center-island and improve the geometric design at this intersection

High priority of signalization
vii) Intersection of Blvd. Norodom / Rue.214
viii) Intersection of Blvd. URSS / Rue Kampuchea Krom /Rue.598 – Rue.271
It is necessary to make major improvement on the geometric design at this intersection
ix) Intersection of Rue. Kampuchea Krom / Rue.109
x) Intersection (roundabout) of Blvd. S. P. Sihanouk / Blvd. Preah Monireth
It is necessary to remove the center-island and improve the geometric design at this intersection
xi) Intersection of Blvd. Mao Tse Tong / Rue.63 (Rue Trasak Paem)
xii) Intersection of Blvd. Monivong / Rue.310
xiii) Intersection (roundabout) of Blvd. Monivong –NRNo.1 / Blvd. Norodom –NRNo.2
It is not necessary to make major improvement on the geometric design at this intersection

It is preferable to operate the signals with a coordinated control for the 2 intersections crossing Blvd. Monivong, ii) Rue 109 and along Blvd. Charles De Gaulle, due to the short distances between these intersections

6) Traffic signal warrants
Warrants of traffic signal should be considered before its installation, and based on the warrant results, a determination should be made whether installation of a traffic signal is justified.
For reference, a set of eleven warrants formally promulgated in the "Manual on Uniform Traffic Control Devices" by U.S. Department of Transportation, Federal Highway Administration is described as the follows:

The warrants are itemized as follows:
1. Minimum vehicular volume
2. Interruption of continuous traffic
3. Minimum pedestrian volume
4. School crossing
5. Progressive movement
6. Accident experience

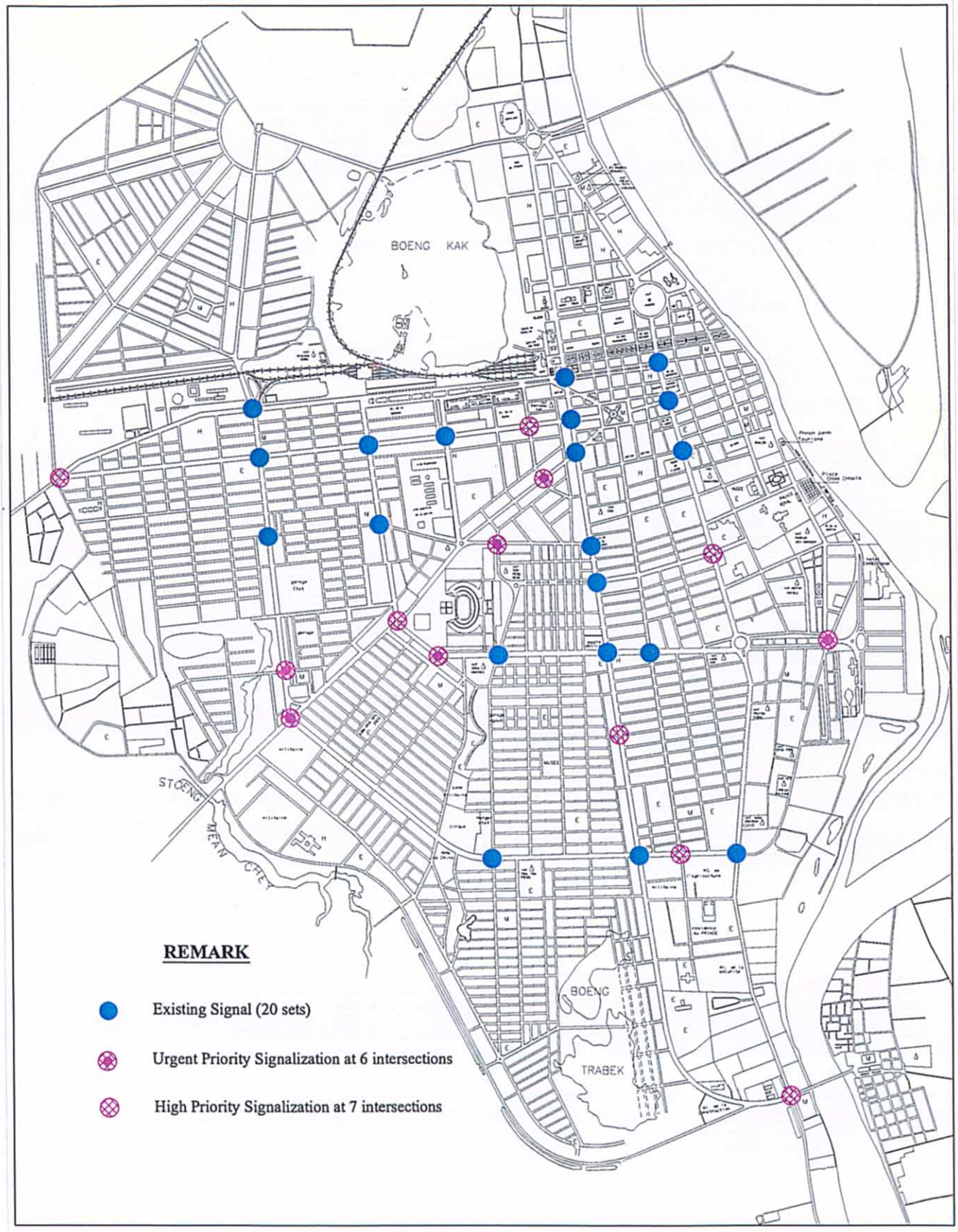

Figure 2.2.7: Intersections to be urgently Signalized

7. System warrant
8. Combination of warrants
9. Four hour volume
10. Peak hour delay
11. Peak hour volume

In case of Warrants 1. and 2., the volume listed in the columns of Table 2.2.5 must be equaled or exceeded during any 8 hours periods of an average per day.

Table 2.2.5: Minimum Vehicular Volume for Warrants 1. and 2.

Number of Lanes for Moving Traffic on Each Approach		Vehicles Per Hour on Major Street (Total of Both Approach)		Vehicles Per Hour on Higher-Volume, Minor Street Approach (One Direction Only)	
Major St.	Minor St.	1. *	2. **	1. *	2. **
1	1	500	750	150	75
2 or more	1	600	900	150	75
2 or more	2 or more	600	900	200	100
1	2 or more	500	750	200	100

* Minimum vehicular volume warrant.
** Interruption of continuous traffic warrant.

These warrants are so important and useful that engineers have to consider them before determining an intersection to install traffic signals.

(4) Basic considerations for determining intersections to be signalized in future

Intersections without congestion at the present will be requied to be signalized to accommodate the future demands effectively. Thus, to predict intersections which are necessary to be signalized, a basic criteria is used in accordance with 3 types of road functions: major arterial street, colloctor streets and local streets. (see Table 2.2.6)

Table 2.2.6: Traffic Controls Depending up Type of Intersections

	Arterial Street	Collector Street	Local Street
Arterial Street	Signalized	-	-
Collector Street	Signalized	Signalized	-
Local Street	-Closure of road -Prohibiting left-turn	Non-signalized	Non-signalized

Signal control should be applied to intersections with two crossing arterial streets, most of which sets of signals are already installed except for roudabout intersections in the urban area of the city. At intersections of a collector street crossing an arterial or another collector street, signal control will also be necessary.

On the other hand, local street intersections are not required to be signalized, furthermore, at the intersections of a local street crossing with an artterial street, it is preferable to operate an access control such as closure of local street or prohibition of left turning to/from the arterial

The following future plan is made based on this criteria.

(5) Future Plan of Signal Operation

In coincidence with increasing traffic demands, and improving the road network and the facilities, the signal operation should be improved. Thus, it becomes necessary to introduce a higher level of signal control in order to accommodate the future demands as well as enhancement of traffic safety in Phnom Penh.

1) Staging Plan for signal improvements
   A staged improvement plan is proposed for the traffic signal facilities, considering the future traffic demand increases and effective signal operation. Figure 2.2.8 shows a stage plan for signal improvements.

Stage Time Period	Signal Control Method	Intersection Group	Number of signalized Intersections
Stage 0 -2000	Isolated Control under Fixed Parameters	Each Intersection	20 Total 20
Stage 1 2001-2005	Isolated Control under Time of day Parameters	Each Intersection	13 Total 33
Stage 2 2006-2010	Coordinated Control under Time of day Parameters	Intersections along Main Route	23 Total 56
	and Isolated Control under Time of day Parameters	Each Intersection	7 Total 63
Stage 3 2011-	Computerized Area Control under Detector Data	Intersections in Area	54 Total 117
	and Taffic information system		

Figure 2.2.8: Stage Implementation Plan of Traffic Signal Operation

In this regard, a staging plan to introduce a new signal system can be made as follows:

Stage 1: From 2001 to about 2005

- The cycle time and splits can be changed according to a time schedule based on time-of-day parameters in weekday, Saturday Sunday and public holiday,
- To operate signals with a synchronized or coordinated control when the distance between two signalized intersections along major streets is too short,
- To signalize all the 33 intersections including the existing signal replacement, which are decided previously in the urgent priority of the signalization plan, as shown in Figure 2.2.9.

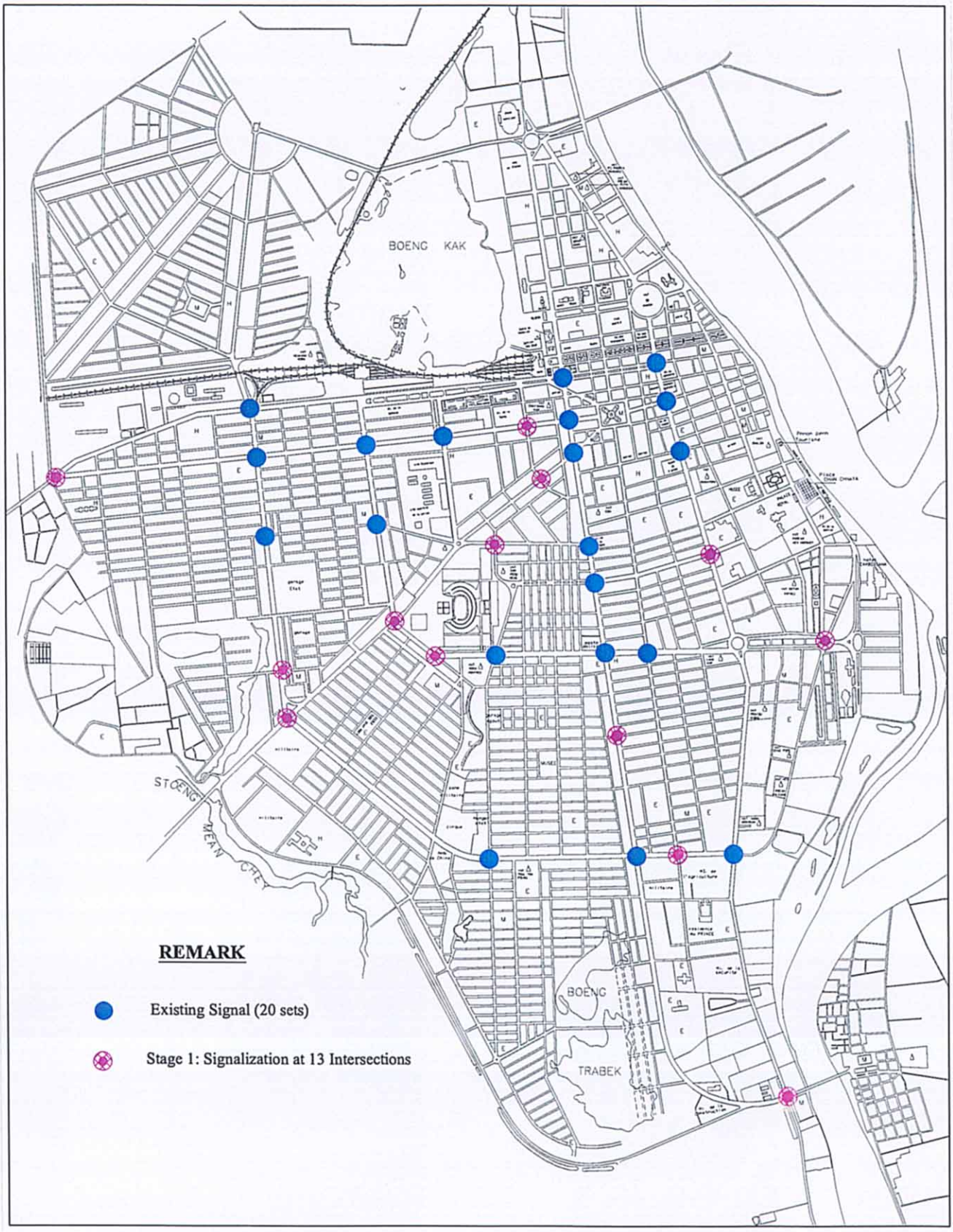

Figure 2.2.9: Intersections to be signalized in Stage 1

Stage 2: From 2005 to about 2010

- To operate signals along main routes using a progressive control in accordance with a time schedule The cycle time, splits and offsets can be changed based on time-of-day parameters in weekday, Saturday and Sunday in order to permit continuos operation of groups of vehicles at a planned speed.

  Figure 2.2.10(1) shows an example of directional preference progress signal control for streets carrying heavy directional peak volumes: these will favor travel in the peak direction.

  Figure 2.2.10(2) shows an example of both directional preference progress signal controls for streets carrying equal volumes in both directions: these will favor travel in both directions.

- Local signal controller may have a time clock adjusted automatically to accurate time in the box in order to coordinate with other signal timings. It is not preferable to install communication cables under the ground by MPP.
- To operate signals at the other intersections using the same isolated control as Step 1
- To install approximate1y 56 sets of coordinated signals and approximate1y 7 sets of isolated signals
- The candidate routes for a progressive control are as follows:
  - Blvd. Monivong
  - Blvd. Norodom
  - Blvd. URSS
  - Blvd. Rue Kampuchea Krom
  - Blvd. C. De Gaulle-Blvd. Preah Monireth
  - Blvd. Mao Tse Tong
  - Blvd. S. P. Sihanouk

Figure 2.2.11 shows the candidate routes and the groups of intersections for a progressive signal control in Stage 2.

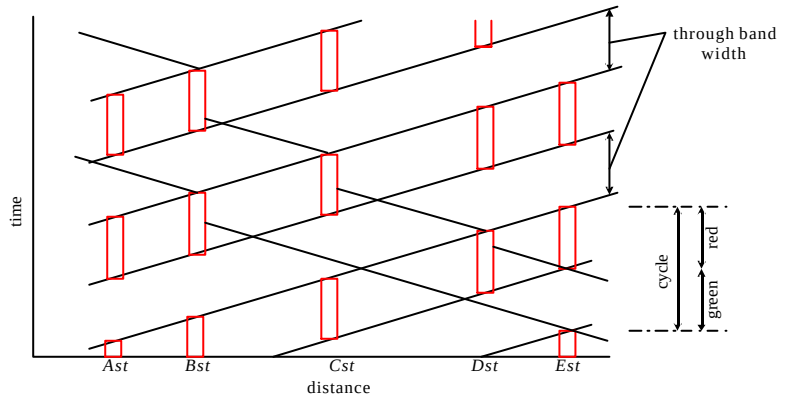

Figure 2.2.10 (1): Directional preference and progressive signal control, especially for peak hours

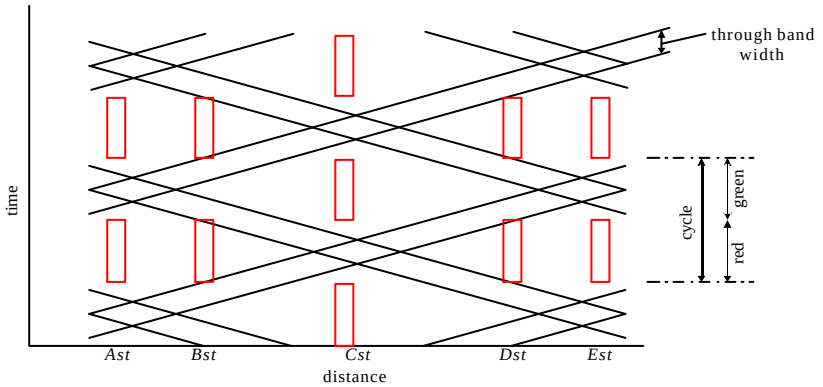

Figure 2.2.10 (2): Both directional equal progressive signal control, especially for off-peak hours

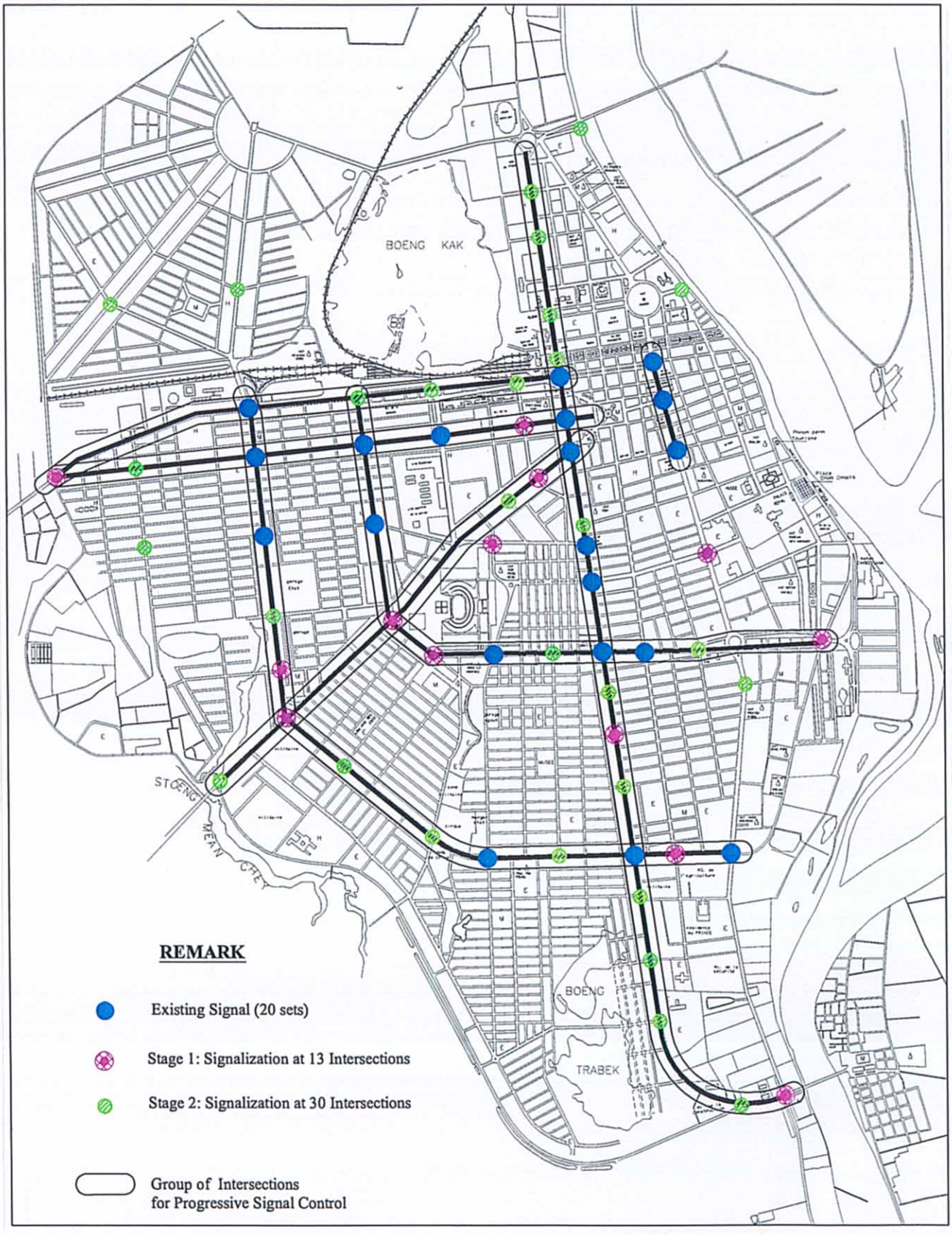

Figure 2.2.11: Intersections to be signalized in Stage 2

Stage 3: After 2011

Stage 3 Traffic Control System should comprise of 2 main functions: Area signal control system and Traffic information system.

1) Area signal control system
   - A computerized area signal system with a centralized traffic control center is proposed to be introduced to Phnom Penh.
     This system is a traffic-responsive technique for generating coordinated signal timing or selecting a pattern of coordinated signal timings for the city network in real time. Traffic flows at the main intersections are measured by vehicle detectors and used to decide such signal timings as cycle, split and offset by centralized computers for all the intersections covered by the system.
   - To construct a traffic control center in a Municipal Building
   - To use a public communication cable network.
   - To centrally and remotely operate approximate1y 117 sets of signals from a traffic control center.
   - To install vehicle detectors on strategic locations on streets

   Figure 2.2.12 shows intersections to be operated under a computerized area signal control system in Stage 3.

2) Traffic information system
   - Information services provided by changeable message signs, radio broadcast based on the continuous traffic monitoring by vehicle detectors or TV cameras are common in the world.
   - Information collection,
     - Traffic information:
       Traffic volume, occupancy rate, estimation of jam length and travel time etc.
     - Weather information:
       Rainfall, wind velocity etc.
     - Information concerning regulation:
       Temporary regulations due to festivals, road works, floods etc.
   - Measures of disseminating traffic information
     - Changeable message signs:
       Free pattern message signs are put into use
     - Radio broadcast:
       The center serves information through public and/or commercial broadcast.
     - Telephone guide and Facsimile guide:
       The center answer telephone and facsimile inquiry concerning route guidance, traffic conditions or days of special events etc.
     - Route guidance system:

   The principle of comprehensive automobile control is that each vehicle installs device which transmit its destination and a few necessary information to a center and receives information from the center on route selection and displays them on a TV screen in the vehicle. Although there are several techniques and methods, communication between vehicle and the center are commonly done via satellite or road side devices.
   - Guidance system of parking locations
     The system is to monitor occupancies parked in such locations as parking buildings and public parking lots in each district, and to guide cars to an available parking place by means of parking message sign boards installed along the approach roads.
     The information can help road users find an available parking place easily, and contribute to reduce congestion.

3) Assumptions for computerlized area signal system
   To introduce a computerized area signal system, situations of motorcycle usage on streets and communication cable network in Phnom Penh in the future has to be assumed or forecast as follows:

a. Motorcycle usage on streets

Both types of vehicle detectors using loop coil and supersonic can not detect exactly motorcycles passing on the roads. When motorcycle usage is still large in the future, it is not preferable to apply these detectors to the streets of Phnom Penh in order to operate real-time signal control in respond to demands. If required now or in future, image sensing detectors may be used to count the number of motorcycles.

Fortunately, the master plan on transportation in the Phnom Penh Metropolitan has mentioned that the number of motorcycles will decrease by shifting to modes of mass transit, 4 wheel vehicles and so on in the future, thus, the existing vehicle detectors will be used in about 2015.

b. Communication cable networks

In relation to the recent development of information technology in the world, it is expected that a large scale public communication cable network will cover the city of Phnom Penh by about 2015.

A computerized area signal control can be operated efficiently and sufficiently using the cable network. If it is required now or in the near future, the MPP has to install its own communication cables under ground.

c. Candidate locations of a traffic control center

The followings are the candidate place to locate a traffic control center to control all the signals and to serve traffic information to road users.

i) The main Municipal Office building
ii) The DPWT building

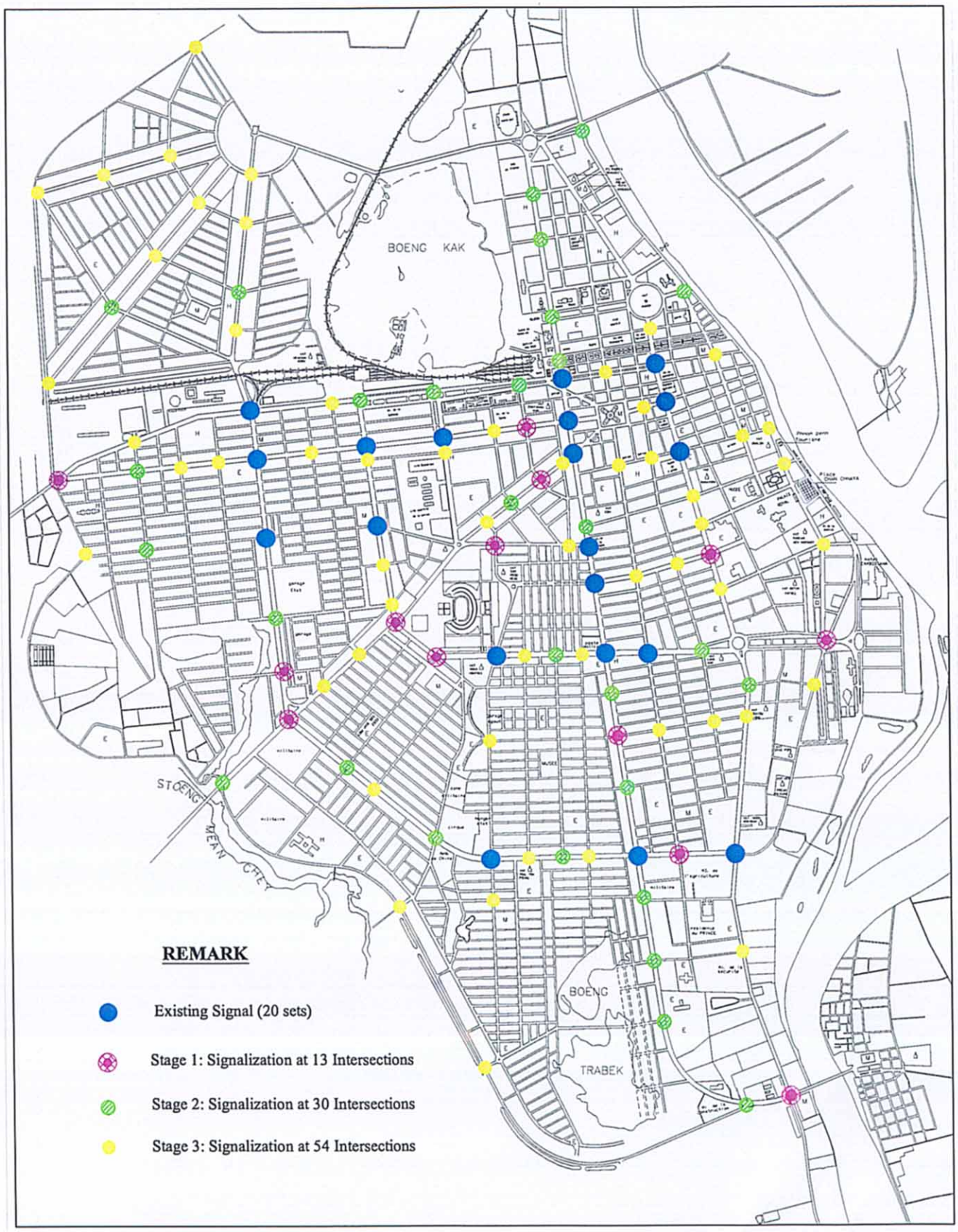

Figure 2.2.12: Intersections to be signalized in Stage 3

2.2.4 Introduction of a System of Traffic Accident Data Base and Analysis

Streets and roads are the life lines necessary for the daily living and social activities. If they are not well maintained, they can lead to various inconveniences, fall of economic productivity, increases in living costs and finally dangers or even deaths to the public.

A traffic manager has the responsibilities of planning, designing, constructing and maintaining and putting them into practice continuously for the purpose of public safety and the effective use of roads and streets. If traffic accidents happen at a certain area frequently, it implies that the road has some inherent defects even though it may not be a fatal defect from road design or construction.

To eliminate and alleviate such inherent defects, therefore it is suggested that a system to search and identify the high frequency accident locations be introduced, which is based on traffic accident data collected, input and analyzed by computer. In addition, it is suggested that ways to implement proper remedial measures to decrease the accidents are discussed in such a system.

(1) Basic Idea

At present, annual statistical traffic accident data are collected manually. However this data alone is not enough to allow for traffic engineering analyses in formulating remedial measures for decreasing accidents.

Therefore it is necessary to introduce a system for integrating such processes as building a database on accidents, analyzing causes of accidents using analytical programs and examining suitable remedial measures in a unified way. The system suggested by this study aims at decreasing traffic accidents effectively in the short term by giving priorities to identifying appropriate measures against high accident locations. A function comprising the following four components shall be included in the system.

a. Setting up database on traffic accidents
b. Identifying high accident locations
c. Analyzing high accident locations
d. Examining the remedial measures

Figure 2.2.13 shows the details of process of work in each function.

(2) Contents of work

1) Setting up database system
Necessary data needed for analyzing traffic accidents can be input and stored in the computers, which will be distributed to every district police office and these data will be integrated as the database. Traffic police in each district will be trained to use such a database and how to update it continuously and send them to the headquarters. Compiling this data will help write a report on traffic accidents easily.

2) Identifying high accident locations
Traffic engineers should try to focus on improving certain traffic accident hot spots where it is possible to decrease accidents significantly within a limited budget. By introducing this system, it is easy to search such hot spots or high frequency accident locations.

3) Analyzing high accident locations
A repetitive type of traffic accident at a high frequency accident location within 1 to 3 years implies that certain inherent common factors are causing such traffic accidents. Drawing a sample from such a particular pattern makes it possible to formulate a remedial measure to deal with such a cause.

4) Improvement of High-Accident Location
a. Determination of remedial measure at a high accident location
The most optimum one must be chosen from several possible measures.
b. Priority of implementing measures.
After having determined the most optimum measure at each high accident location, it is necessary to discuss which point has the higher priority than others for implementing the chosen measure.

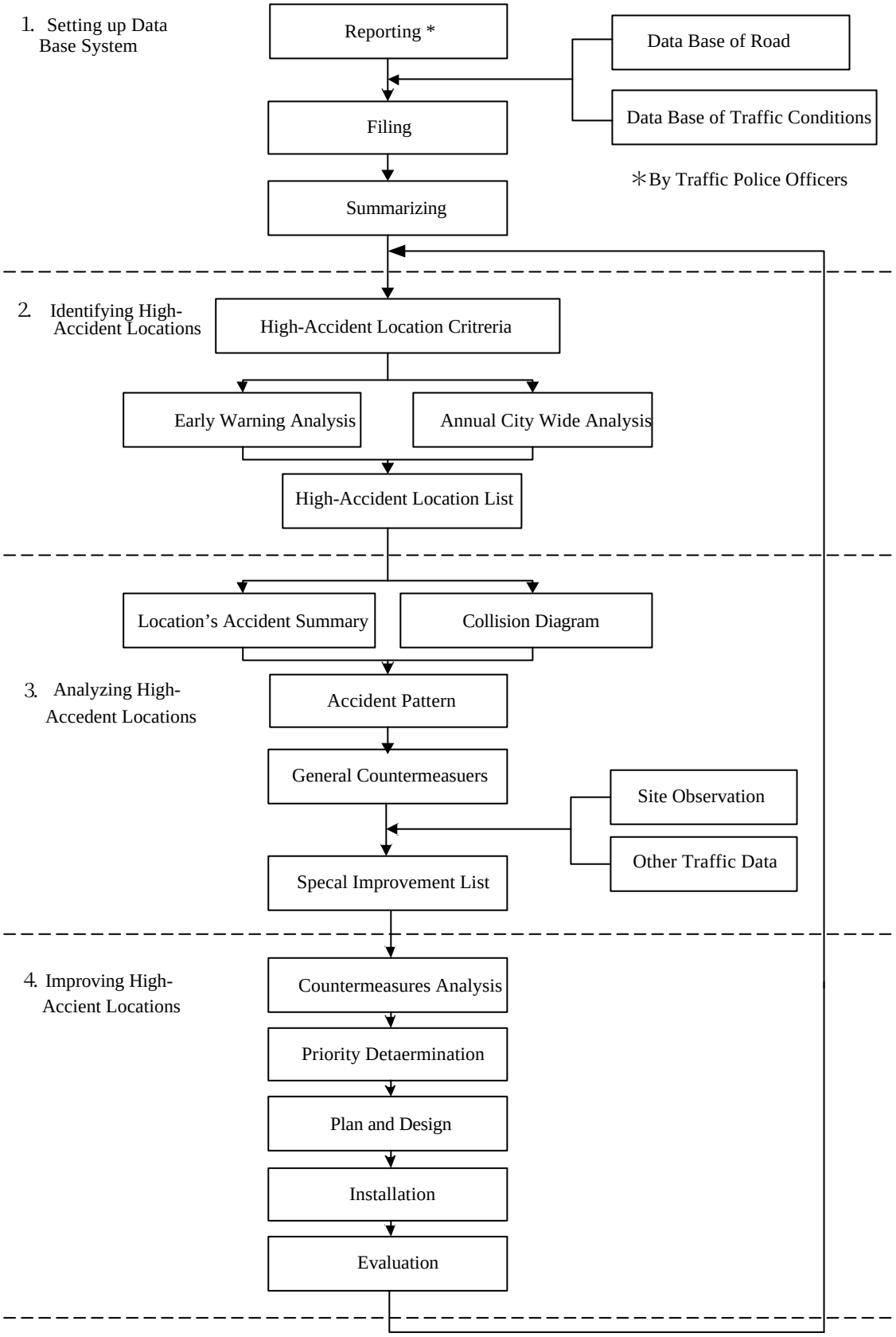

Figure 2.2.13: Procedure and Tasks of Accident Analysis System

c. Implementation of the plan
After having decided the priority, the measure should be carefully designed and carried out.

d. Evaluation of improvement
After the remedial measure has been implemented, it is important to analyze and compare the data on traffic condition and accidents before and after the implementation in order to evaluate the effects of the measure. This process is necessary to improve the effectiveness and accuracy of the remedial methods in order to choose the best measures in the future. The most common method for evaluation is initial and final surveys.

(3) System Configuration

An outline of the system configuration suggested by the study team is given as follows. (It is assumed that the system center is to be located at DPWT - MPP.)

Computer terminal units to input every traffic accident data are to be located in the central police office and seven other district police offices. Every time the data is input on the computer at the district office, it is sent to the central computer at DPWT and MPP on line, which will process the traffic accident data.

The CPU for data processing receives data from each police office, checks it and saves it. Thus, traffic accident raw data is not input at the center.

The following data is also input and saved through the CPU for data processing. These are map of Phnom Penh city, road related data such as forms and types of roads or intersections, and traffic volume data. They are saved in direct access storage device as a database.

Consequently, the CPU for accident analysis will systematically analyzes various kinds of traffic accidents based on the data stored in the computer's memory.

In addition to the above functions, it is possible to obtain various information on traffic accidents at each district police office by accessing to the central computer's build-in memory.

Figure 2.2.14 shows the configuration of the suggested system.

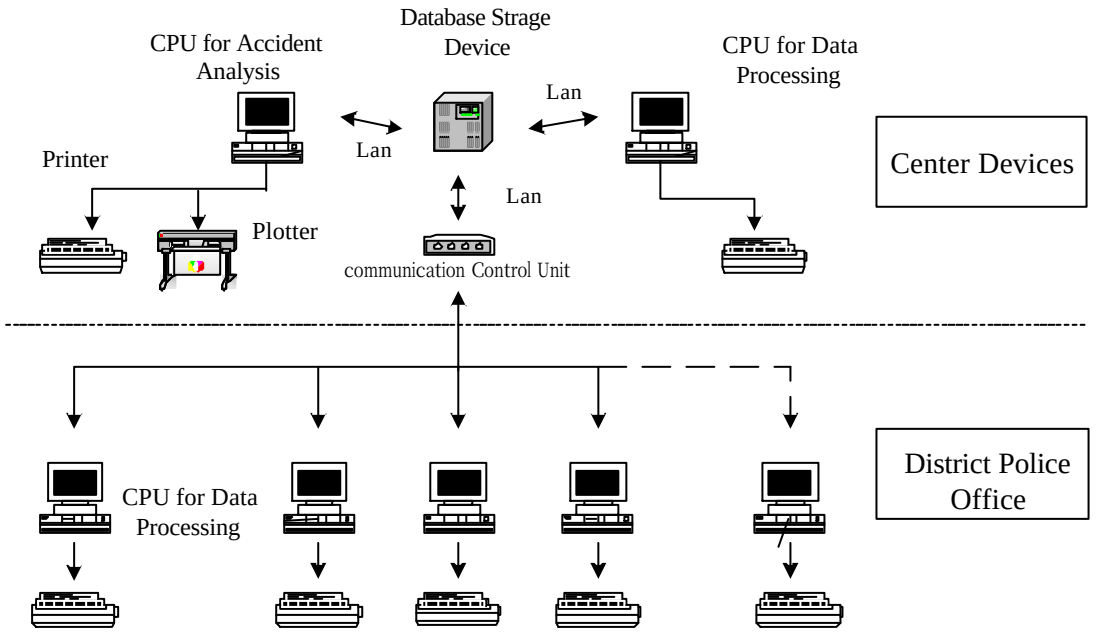

Figure 2.2.14: Equipment Configuration of Accident Analysis System

(4) Merits

The main merits of the system are as follows.

a. It is possible to input data at every police office as a routine work.
b. It is easy to get statistical data related to traffic accidents of the whole city.
c. It is possible to search for a high accident location systematically and this makes accident analysis easy.
d. It is possible to point out general remedial measures at any area to be improved.
e. It is possible to give remedial measures for an area where great effects can be predicted and this brings effectiveness to efforts in the reduction of traffic accidents.

The introduction of this advantageous system would further enhances the effects of road improvements and traffic control measures, based on the analysis on the various traffic accident factors which are largely being ignored at present.

(5) Future Prospects

After this system has become functional, it is also possible to easily combine the installed database with other databases, such as databases on vehicles and drivers, traffic volumes and road inventory. This system has the potential to be developed into a system which contributes to total traffic planning or traffic safety improvement. This means that such tasks as giving education or training to persons who had experienced traffic accidents and managing and controling vehicles that caused accidents will also become easier and systematic.

Figure 2.2.15 shows outline of future system of Basic Data Files and Links in Comprehensive Safety Record-keeping

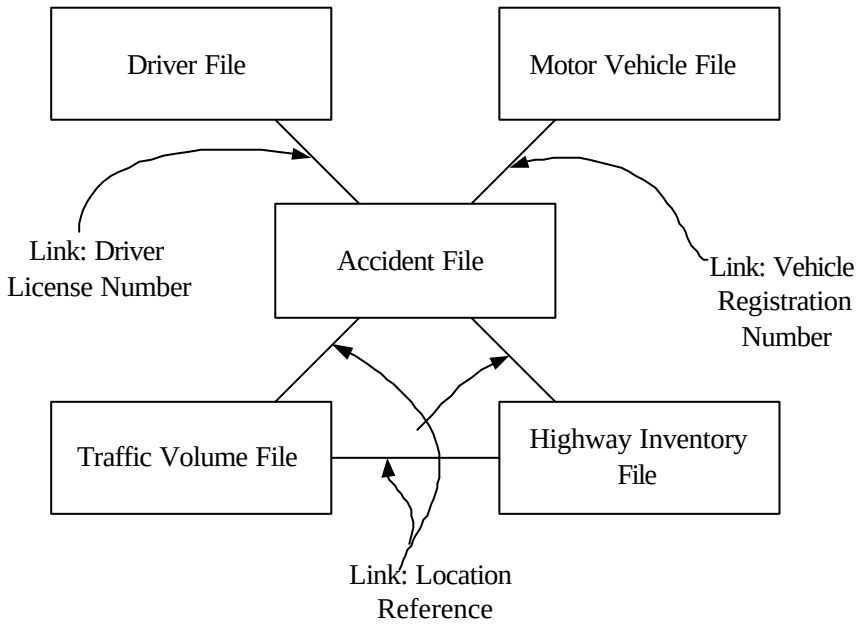

Figure 2.2.15: Basic Data Files and Links in Comprehensive Safety Record-keeping System

2.2.5 Remedial Measures on Traffic Control and Traffic Safety

(1) Importance of Interrelation between Geometric Design and Traffic Control

Geometric design and traffic control are inter-constrained and interdependent, and never separated from each other in designing a road or an at-grade intersection irrespective of whether it is a new construction or improvement. Thus, geometric design and traffic control are always taken into consideration at the same time. A road or an at-grade intersection should be designed with a combination of these factors.

(2) Establishment of an Administrative Section related to Traffic Control and Traffic Safety

At present, DPWT and MPP play the central role in planning, constructing and maintaining urban traffic facilities in Phnom Penh city, while traffic control, especially traffic regulation is conducted by traffic police offices.

As for planning, constructing and maintaining urban traffic facilities, they are unified in DPWT. However they do not go hand in hand with traffic management plan, for example intersection design and signal design are carried out at different departments. In this way, related works are carried out at some independent sections. This causes unstructured traffic arrangement and traffic safety, resulting in many problems which otherwise can be avoided. Therefore, a unified administrative section related to traffic management and traffic safety should be established. The new section is expected to contribute in carrying out a unified operation from planning, designing, and maintaining to management of traffic.

(3) Improvement of Technology

1) Determination of place and method for improvement
   DPWT have suggested improving roads and intersections at present. However it is doubtful that the cost for improving them were used in an effective way.
   Necessity of improvements should be determined by a method based on analyzing past empirical data technically. Using a limited budget to the fullest extent is also an important issue.

2) Lack of engineers
   There are not enough engineers in the field of traffic and transportation engineering at related sections in the Phnom Penh City, as well as in other related fields. In addition, trained engineers fall short of demand. Further education and high level training is a very important issue.

(4) Earmarking Regular Budget

Annual budget for improving or maintaining roads and intersections are much less than that of new construction. New construction projects are carried out within one time budget. On the other hand, budget for traffic control and maintenance of existing road facilities is extremely small although it is required in every year. Some amount of budget should be earmarked regularly for this purpose. Roads should always be kept in good conditions, safe and have enough capacity to handle traffic flow.