5

ATC SYSTEM CONCEPT

CHAPTER 5 ATC SYSTEM CONCEPT

5.1 Necessity and Objectives

The necessity and objectives of ATC system are as follows:

a) The improvement of signal control is one of the ways in which the maximum use of existing road facilities and the increase of road capacities can be achieved. It is a cost effective method.

b) At present, nearly all signalized intersections are controlled manually by traffic policemen, while the efficiency of traffic control can be risen still more by ATC system method.

c) The most significant aim of ATC system is to achieve the smooth flow of motor vehicle traffic. In addition, the ATC system will aim at reducing air pollution and decreasing traffic accidents through alleviation of traffic congestion.

5.2 Functions

In accordance with the objectives cited in the preceding section, the ATC system for Bangkok requires the following functions:

1) Area Wide Coordinated Signal Control Function

The system should be able to respond to changes in traffic conditions based on detectors, and manual control system can be operated in case of emergency condition.

2) Information Function

The system should be able to provide traffic condition information on display board in the control room, the information should be able to monitor by detectors. A commander of operating and radio broadcasting announcer can see the information.

3) Data-Processing Function

The system should be able to compile and process data obtained from the detectors at key intersections in order to update its statistics. Based on this function, it will be able to renew its singal control parameters as necessary and improve its control methods.

4) Monitoring Function

The system should be able to monitor local controllers and detectors, and keep a check on whether they are operating in accordance with central computer commands.

5.3 Intersections to be Covered by ATC

5.3.1 Identification

Based on the ATC Planning Area defined in Chapter 3, intersections that are currently signalized and those that will be signalized were identified as intersections subject to control by the ATC System. Intersections to be signalized consist of those being planned by the BMA (including intersections to be created by the construction of planned roads); those which will be created by the construction of the ETA Expressway (Second Stage) ramps and which are considered to be important; and U-turn signalized intersections. (The signalized intersection for U-turn behavior will be established on this side of the key intersection, it is no necessity that vehicle turn at key intersection. Therefore, the saturation degree of key intersection will be decreased. The U-turn signalized intersection should be located crossing with big soi relatively.)

As shown in Table 5.3.1, a total of 235 intersections were identified, of which 198 are already signalized, 32 will be signalized, and five are U-turn signalized intersections. Fig. 5.3.1 gives the locations of these intersections.

Table 5.3.1 Identified Intersections

Year	Existing Signalized Intersections	Planned Signalized Intersections	U-turn Signalized Intersections	Total
1993	198	32	5	235

The BMA plans to signalize 23 intersections in the Planning Area as shown in Fig. 5.3.1.

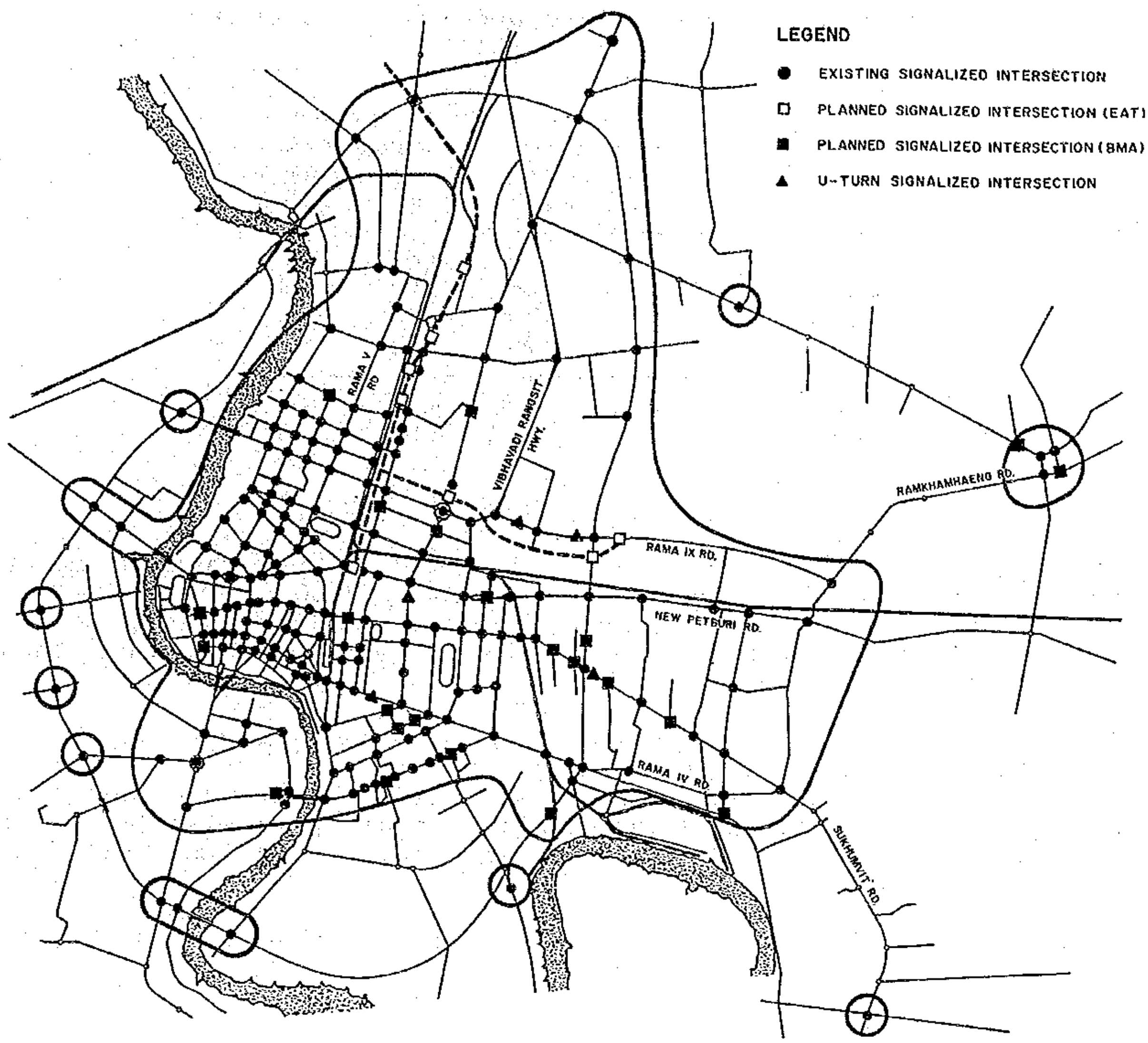


Fig. 5.3.1 Signalized Intersection to be Covered by ATC

The decision on whether to signalize an intersection primarily for the purpose of processing vehicular traffic should be based on the relationship between road width and traffic volume. For urban intersections, the standards are as follows: When the major approach has a width of 10m or more, signal control is warranted if the volume of traffic on the major approach and the volume of traffic on the minor approach with the greatest number of turning vehicles exceed the minimum values given in Table 5.3.2. Since the above-mentioned intersections to be newly signalized by the BMA have two-way traffic volumes of 900-5,800 vehicles per peak hour on their major approaches and 140-2,400 on their minor approaches, they satisfy these standards (see reference). Traffic volumes were obtained from the results of a trip assignment based on the two-way reversible lane system discussed in Chapter 4.

Table 5.3.2 Road Width and Traffic Volume

Road Width		Two-way Traffic Volume on Major Rd		Volume of Traffic on Minor Approach with the Greatest No.	
Major Rd	Minor Rd	12 Hours	Peak Hour	12 Hours	Peak Hour
		10,000	900	3,800	350
Above	Under	12,000	1,000	3,100	270
10m	10m	15,000	1,400	2,000	190
		20,000	1,800	1,450	140
		10,000	900	4,500	420
Above	Under	12,000	1,000	3,500	320
10m	10m	15,000	1,400	2,500	220
		20,000	1,800	1,700	160

Within the Planning Area, there are nine points where a major road connects with a planned ETA Expressway ramp as shown in Fig. 5.3.1. Two-way traffic volumes on major roads at these points range between 1,400 and 5,800 vehicles per peak hour and thus warrant signal control.

The decision on where to provide U-turn signal control was based primarily on the criteria whether several of the following conditions are met: there are key intersections nearby; the link length is long; there is a median; the motorway is wide (at least 4 lanes in two directions); there are many soi in the link; and traffic volume is heavy.

Based on the foregoing, five points were selected for U-turn signal control as shown in Fig. 5.3.1.

5.3.2 Categorization

1) General

The above-mentioned 235 intersections subject to control by the ATC System were divided into 54 key intersections and 181 ordinary intersections. A key intersection serves as the base point for determining the ATC cycle, split and offset. In principal, the key intersection will be controlled based on responsive system received from detectors. Fig. 5.3.2 shows the locations of key intersections.

2) Key Intersections

The following conditions and criteria were used to select key intersections:

(a) At least one of the approaches must be a major road (arterial or semi-arterial) in the ATC Planning Area.

If an intersection satisfying the above condition has a saturation degree of at least 0.7 from the consideration of processing traffic volume fluctuation and very low travel speed, it is categorized as a key intersection.

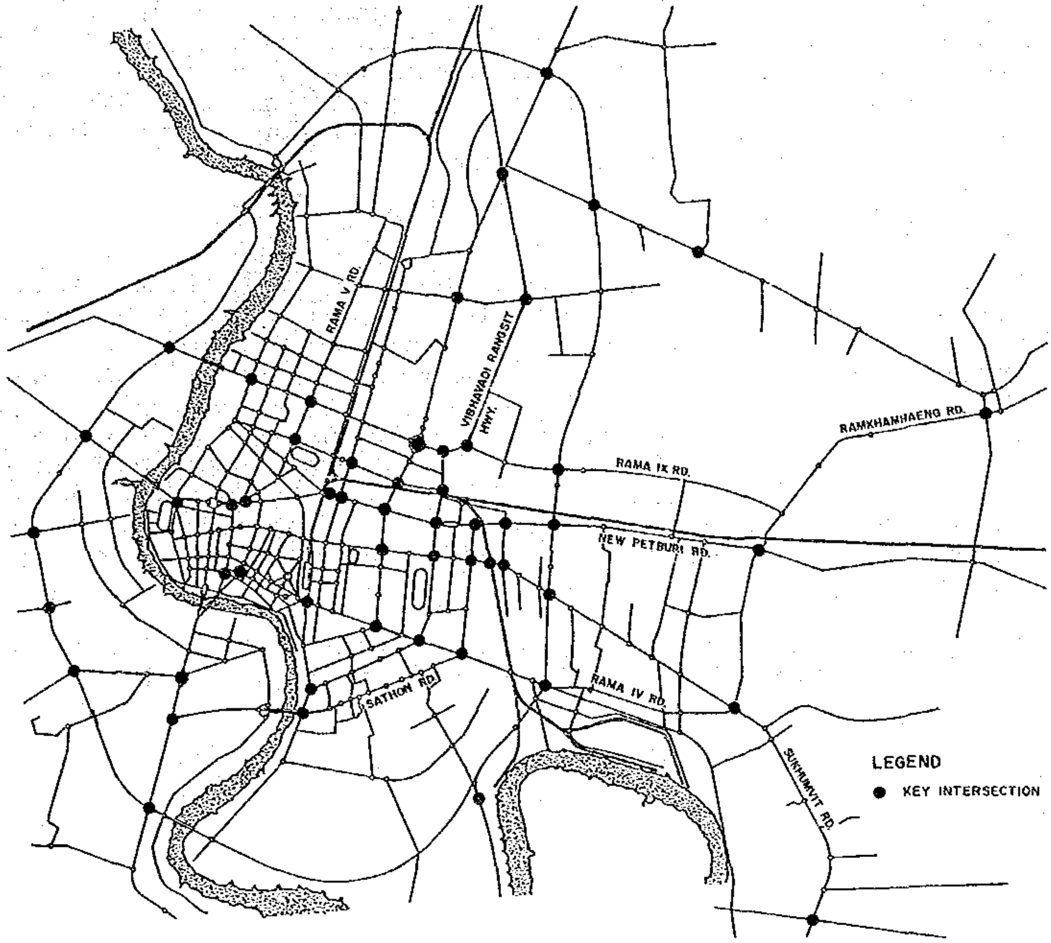


Fig. 5.3.2 Key Intersection

(b) Based on a study of the road network in the target year, ETA Expressway ramp intersections which are considered important from the standpoint of processing traffic are categorized as key intersections.

5.4 Control Concept

There are three major reasons why it is essential to have a traffic-responsive system for controlling traffic in Bangkok:

- There is a high degree of saturation.
- Splits must be precisely controlled to meet traffic demand fluctuations.
- Traffic demand fluctuations are highly random.

Traffic-responsive control systems range widely from very complicated systems to simpler systems.

A traffic control system for Bangkok must be able to respond effectively to the different traffic conditions seen in the city in terms of saturation degree, particularly to the long periods of near and oversaturation that take place in the afternoon hours. Taking into account this special need, the study discussed in this section was conducted in order to arrive at the most cost effective method of operating the ATC system for improving traffic flow in Bangkok, without being influenced by the existing signal control system.

5.4.1 Basic Principles

As mentioned in the preceding section, signalized intersections are divided into key intersections, which serve as focal points for signal-controlling the overall network, and ordinary intersections. These two groups will be controlled separately.

The ATC system will automatically assess the saturation degree of key intersections based on on-line data received from detectors at these intersections, and will apply different control methods depending on the degree of saturation. At the same time, control of ordinary intersections will be subordinated to that of neighbouring key intersections.

Traffic conditions at key intersections are divided into three types as defined below and outlined in Fig. 5.4.1.

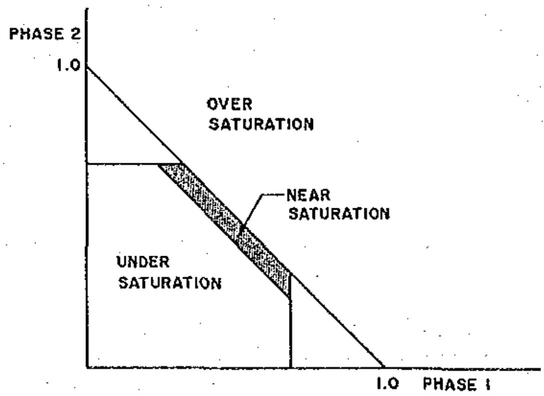


Fig. 5.4.1 Classification of Traffic Condition

1) Undersaturation

The condition wherein vehicles arriving in the last cycle time are all cleared in the current green, on all approaches to the subject key intersection. Traffic demand per cycle is less than intersection capacity.

2) Near Saturation

The condition wherein vehicles arriving in the last cycle time are not at times cleared in the current green depending on the cycle, in any given phase. Traffic demand per cycle is more or less equal to intersection capacity.

3) Oversaturation

The condition wherein vehicles arriving in the last time cycle are not cleared in the current green on a continuous basis, in any given phase. This condition may correspond to either (a) traffic demand per cycle is over intersection capacity or (b) traffic demand per cycle is less than or almost same as intersection capacity, but there are unprocessed vehicles left over from past cycles. A long queue develops at the subject intersection, preventing traffic at the upstream intersection from moving ahead.

5.4.2 Basic Control Methods

1) Undersaturation

Cycles and offsets will be controlled so as to minimize the performance index: e.g. total delay time or total number of stoppages within the overall network, or the weighted sum of the two.

Splits at key intersections will be made proportional to the saturation degrees of subject phases. At ordinary intersections, the split in the direction of the major road leading to the neighbouring key intersection will be longer than the split chosen for that key intersection.

2) Near Saturation

Since traffic demand and intersection capacity are more or less equal under near saturation, slight changes in traffic demand or delays in follow-up signal control can easily trigger the development of queues and lead to oversaturation. Because of this unstable situation, the greatest care must be exercised in processing traffic. At the same time, it is necessary to apply a control method that prevents oversaturation or at least delays oversaturation as much as possible.

Under conditions of near saturation, traffic demand per cycle fluctuates widely, causing queues to form and disappear repeatedly. Therefore, it is important to adjust the splits sensitively so as to respond quickly to traffic demand fluctuations and maximize intersection throughput. In addition, offsets should be progressive so that vehicles moving toward key intersections always receive the green indication.

3) Oversaturation

Since there is a continuous store of vehicles needing clearance under conditions of oversaturation, it is necessary to take queue length restrictions into account before determining cycle lengths and splits for maximum throughput. In addition, offset should be reverse-progressive since it is especially necessary, given the functions of key intersections, to allow vehicles to pass through key intersections smoothly.

4) Other Control Methods

Other control methods that must be reviewed include (a) right-actuated control, which can raise the efficiency of phases for minor right-turning traffic in order to help maximize intersection capacity, and (b) control to cope with spill packed phenomena resulting from accidents.

The discussion above is summarized in the following table:

Table 5.4.1 Control Strategies for Different Traffic Conditions

	Undersaturation	Near Saturation	Oversaturation
Cycle (A)	Min. Performance Index	Max. throughput	Max. throughput
Split (B)	Min. Performance Indes	Max. throughpu	Max. throughput
Offset (C)	Progressive	Progressive	Reverse progressive

Notes: (A): Sub-area (group of intersections that are coordinated based on the same cycle length)
(B): Intersection
(C): Link

Notes: (1) Performance Index: total delay time or total number of stop pages on the weighted sum of two.

(2) Progressive offset means that vehicles moving toward key intersections always receive the green indication. Reverse-progressive offset means that vehicles moving away from key intersections always receive the green indication.

In addition, the above control methods are classified according to type in the following table:

Table 5.4.2 Control Mdethods for Different Traffic Conditions

	Undersaturation	Near Saturation	Oversaturation
Cycle	Plan selection	Plan selection	Plan selection
Split	Plan selection	Plan formation	Plan formation
Offset	Plan selection	Plan selection	Plan selection

Notes: (1) Plan selection means that plans prepared off-line in accordance with forecast patterns of traffic condition are selected every 15 minutes or so based on data received from detectors.

(2) Plan formation means that signal control plans are prepared on the basis of cycle-to-cycle fluctuations in traffic demand as indicated by detectors.

When a key intersection is in a state of network oversaturation, traffic at the key intersection is unable to move forward. Therefore, control parameters that can alleviate this situation will be selected by taking into account traffic conditions at the subject intersection, as well as traffic conditions at neighbouring intersections.

5.4.3 Equipment and Devices

1) Detectors

Detectors will be provided for the purposes of supplying data for determining control parameters.

Detectors supply raw data on traffic conditions (under, near or oversaturation) at key intersections which are necessary for determining signal control parameters (cycle length, split and offset). These detectors will be positioned at points appropriate to obtaining such data.

There are two types of detectors: the loop-inductive type and the ultrasonic type. The type that best fits the local environment will be chosen.

2) Local Controllers

Local controllers will be installed at all intersections and linked to the control center on an on-line basis. Their functions are to control traffic signals in an appropriate manner and to transmit data obtained from nearby detectors.

3) Central Processing Unit

(a) Host Computer

The host computer calculates signal control parameters based on data supplied by detectors and in accordance with established control methods. It can communicate with operators via man-machine interfaces such as peripheral devices and wall map displays.

(b) Front-End Processor

The front-end processor processes raw data received from detectors via local controllers and sends the processed data to the host computer. It also receives signal control parameters from the host computer, processes the data and sends them to the local controllers. By undertaking part of the high-speed real-time routine tasks required of a central processing unit, it helps to raise the performance of the host computer.

4) Reversible Lane Control System

Reversible lane control systems will be provided in sections where reversible lane operation is to be introduced, as discussed in Chapter 4. It consists of an overhead sign and a signal aspect mounted on a gantry that spans the roadway. They are synchronized with signal control and the sign will notify drivers of the direction in which the reversible lanes are being operated.

5) Man-Machine Interfaces

In addition to the host computer and front-end processor, the control center is equipped with various man-machine interfaces that allow communication between operators and the computer. They are as follows:

- Wall map display
- Operation consoles
- Graphic CRT
- Computer peripherals
- Others

6) Other Equipment

The following facilities are necessary for the ATC system:

- Uninterruptible power supply
- Air conditioner
- Modem and main distribution frame
- Radio broadcasting booth
- Radiotelephone

7) Dual System

It is important to ensure that the ATC System is highly reliable owing to the strong dependence on road transport seen in Bangkok. In particular, a failure of the system between the host computer and local controllers can have an extremely serious effect on transport activities in the city. Therefore, the following components of the System should have dual equipment:

- o Host computer
- o Front-end processor
- o Communication system between center and local

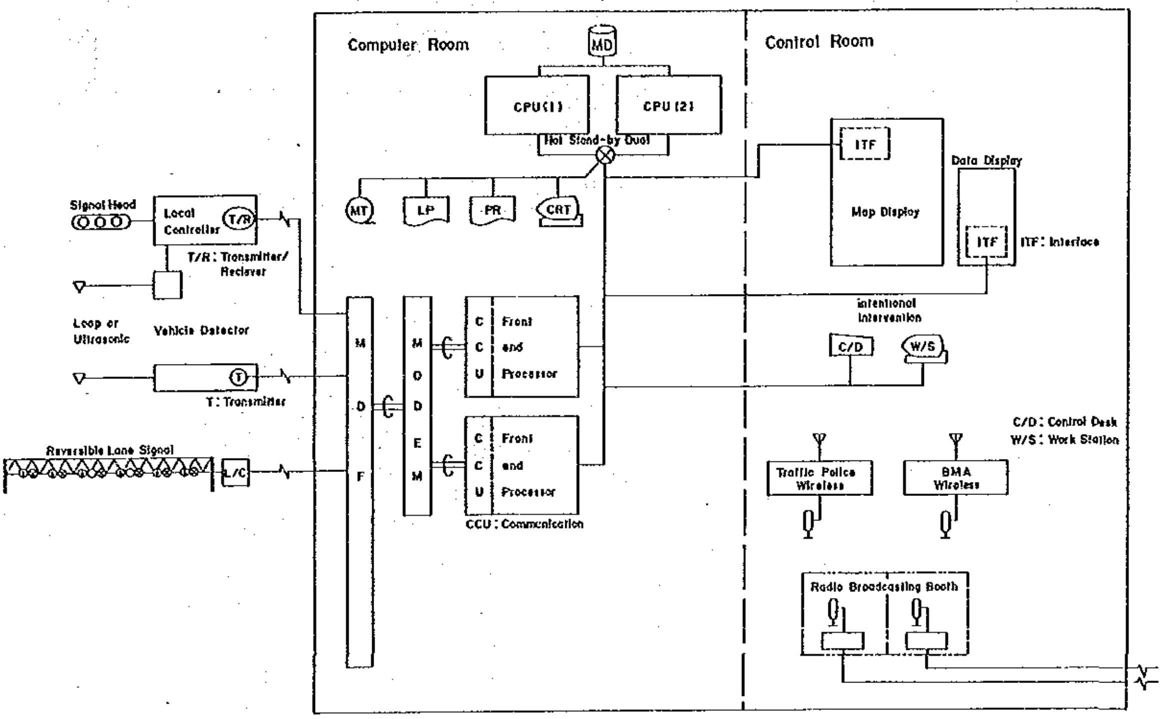


Fig. 5.4.2 Conceptual ATC System Configuration Diagram for Bangkok

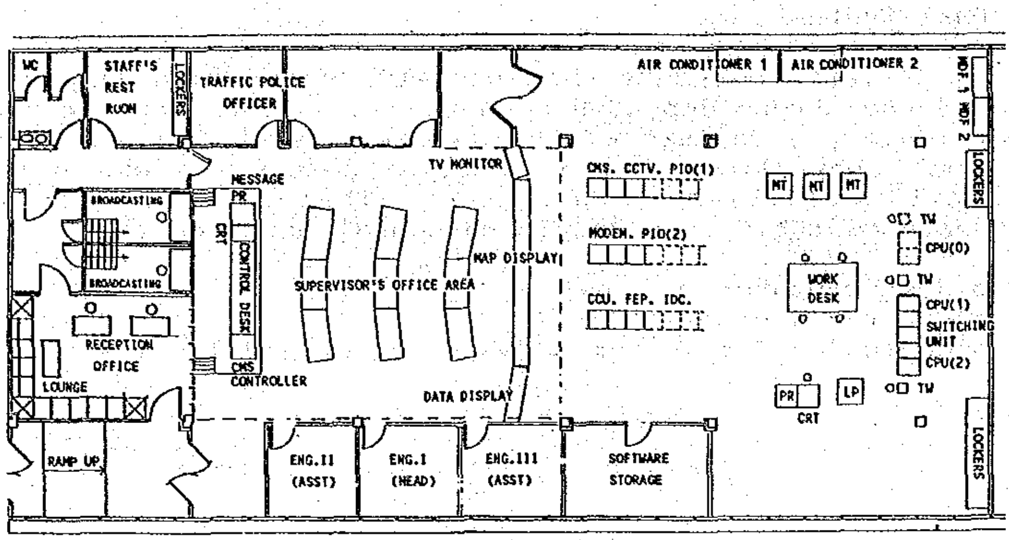


Fig. 5.4.3 Lay-Out Central Equipments

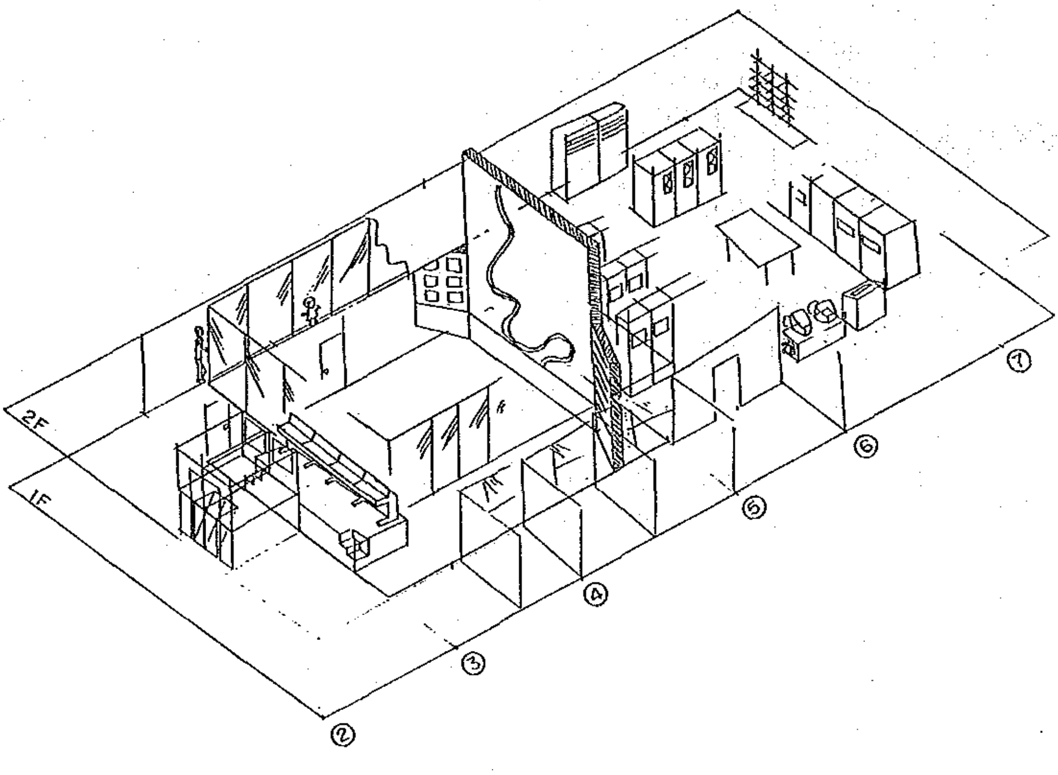


Fig. 5.4.4 BIRD's Eye View of ATC Center

5.4.4 Organization

- In order to maintain a desirable condition of ATC system mentioned above, it is necessary that an organization for system operation and maintenance should be arranged sufficiently.

- In regard to operation, the appropriate operating organization should be established from the consideration of processing system area extension, grade up of system and coordinating to other organizations. The operating staff who has sufficient technique and experience should be prepared. The following main activities are necessary for operation: Signal planning and system area extension, traffic survey, signal design, system operating and control, etc.

- In regard to maintenance, the maintenance organization should be established in order to support regular maintenance and prevention of troubles related to system equipments. The following main activities are necessary for maintenance: Inspection, repairment, etc.

6

PRELIMINARY DESIGN

CHAPTER 6 PRELIMINARY DESIGN

6.1 Future Traffic Volume

In order to prepare a preliminary design of the ATC System, the volume of future vehicular traffic was forecast. The method and results are discussed below.

6.1.1 Forecast Method

The volume of vehicular traffic in 1993, the target year for the operation start of the ATC System, was forecast in accordance with the following conditions. The traffic assignment procedure is given in Fig. 6.1.1.

1) Road Network

The road network subject to traffic assignment corresponds to the Future Road Network (1993) discussed in Chapter 3. Accordingly, a part of the ETA's Second Stage Expressway that is scheduled to be opened by 1993, as well as the Rama IV viaduct, the Soi Asoke elevated road, and the Ring Road flyover that are to be completed by the target year, were taken into account.

2) Vehicles OD Data

Vehicles OD data are based on the results of the car OD survey conducted in 1985 as part of the JICA Study. The "Vehicles OD Distribution Matrix in 1985" was adjusted in accordance with the growth rates established in the current Study applicable to the volumes of traffic generation and attraction in each of the 1993 zones.

6.1.2 Forecast Results

Vehicular traffic in 1993 was assigned to the subject network on the basis of the forecast conditions mentioned above. Fig. 6.1.2 shows the volume of traffic during the morning peak hour, and Fig. 6.1.3 shows the volume of traffic in the evening peak hour.

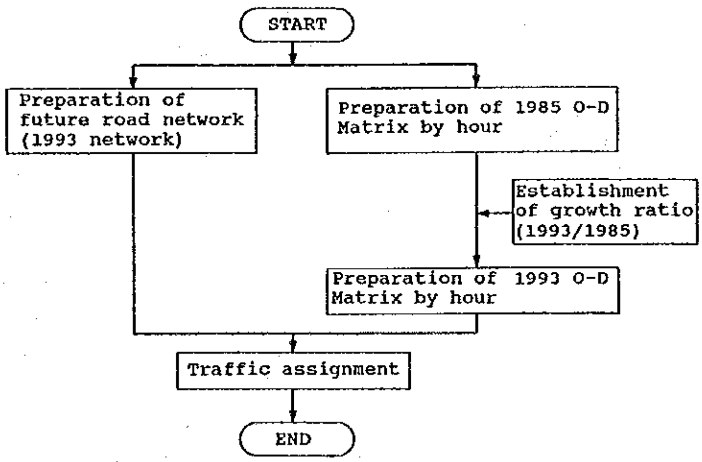


Fig. 6.1.1 Procedure of Traffic Assignment

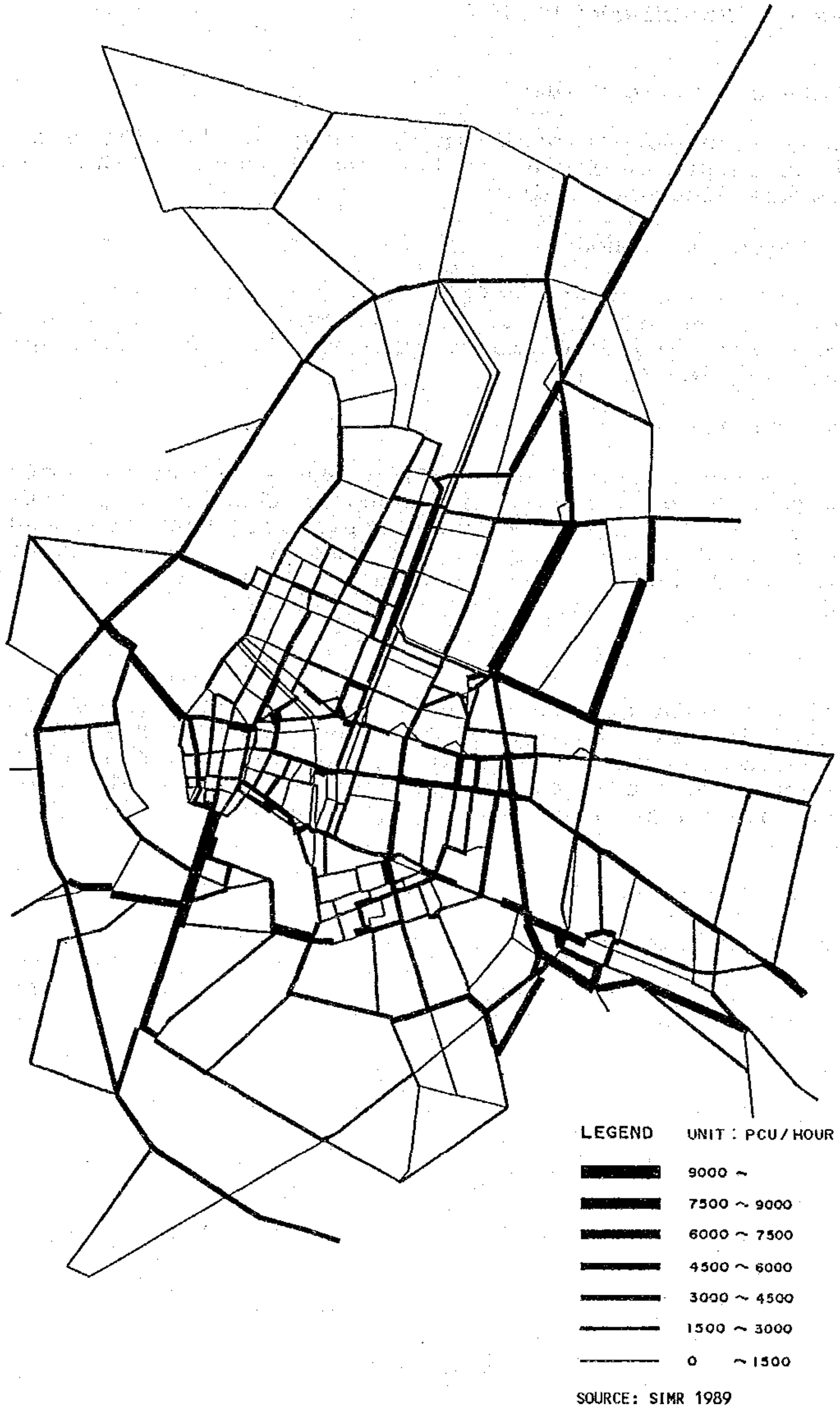


Fig. 6.1.2 Future Traffic Volume in 1993
(Morning Peak Hour)

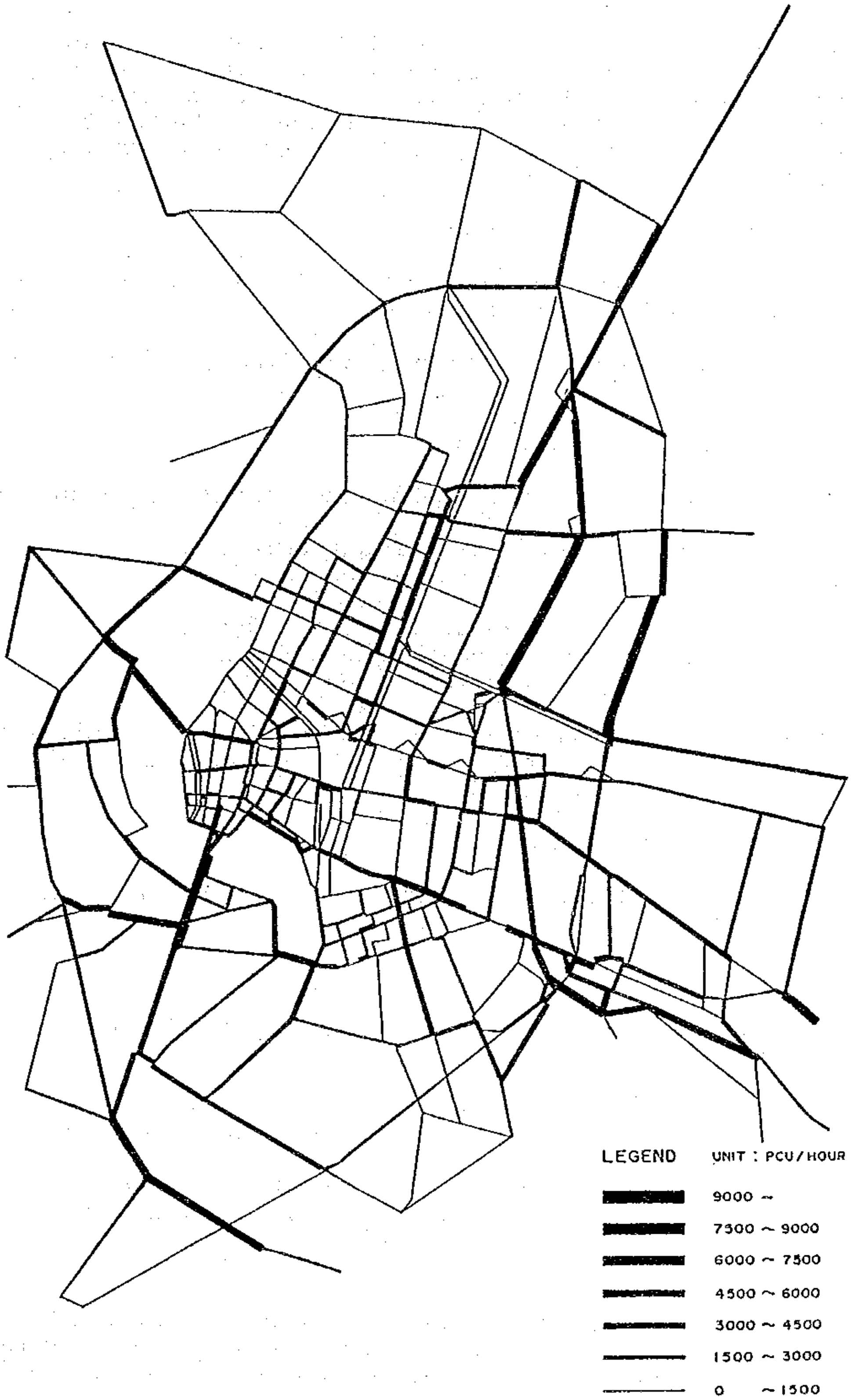


Fig. 6.1.3 Future Traffic Volume in 1993
(Evening Peal Hour)

6.2 Traffic Engineering Measures for ATC System

Along with the introduction of the ATC System, it is necessary to implement traffic engineering measures that can enhance the beneficial effects of the System. This section discusses some of the traffic management facilities that should become necessary in conjunction with the installation of ATC System signal facilities.

6.2.1 Intersection Improvement

Channelization plans were reviewed for intersection improvements based on the following factors:

- o Traffic Circulation Plan (including the reversible lane plan)
  - Reversible lanes
  - Traffic regulations

- o Lane operation improvement for handling future traffic flow
  - Addition of exclusive right-turn lanes
  - Improvement of channelizing islands

- o Installation of planned traffic signals
  - Planned-signalized intersections
  - U-turn signal intersections

These reviews were conducted by taking into consideration the 1993 traffic volume, the existing shapes of the subject intersections, and existing plans.

1) Subject Intersections

The intersection improvement plan covers the 235 intersections that are to be controlled by the ATC System.

2) Plan Conditions

The intersection improvement plan was prepared on the basis of the following conditions:

a) Intersection improvement works shall be implemented without increasing the existing road width.

b) As a general rule, the results of the 1993 traffic assignment that takes into account the Traffic Circulation Plan shall be used for the future traffic volume.

c) As a general rule, lanes shall be operated as exclusive lanes. However, where there are width limitations, the lanes shall be operated as mixed-vehicle lanes.

d) As a general rule, minimum lane width shall be 3.0 meters. However, the minimum width of additional lanes shall be 2.75 meters.

3) Improvement Plan

In conjunction with the reversible lane of existing signalized intersections, as called for in the Traffic Circulation Plan, a pavement marking plan for the intersections was prepared in order to achieve the smooth flow of traffic. In addition, in conjunction with the installation of traffic signals at non-signalized intersections, a channelization plan for these intersections was prepared in order to control traffic flow on major and minor approaches and to ensure the safety of pedestrians.

These improvements are listed in Table 6.2.1. Salient points of the improvements are discussed below.

Table 6.2.1 Improvement Measures

Improvement Measures	Traffic Circulation Plan	Lane Operation for Future Traffic Flow	Planned Signalized Intersection
1. Improvement of pavement markings where lane operation is to be altered	•	•	•
2. Addition of exclusive right-turn lane	•	•	•
3. Improvement of channelizing island	•	•	•
4. Improvement of median	•		•
5. Installation of pedestrian crossing	•		•
6. Improvement in conjunction with introduction of reversible lanes	•		•

a) Improvement of Pavement Markings where Lane Operation is to be Altered

Pavement markings such as arrows, stop lines, and center lines will be improved at intersections where the one-way regulation is to be altered or where the system of lane operation is to be altered due to changes in traffic demand.

b) Addition of Exclusive Right-Turn Lanes

Exclusive right-turn lanes will be established at intersections with a high volume of right-turning traffic, in order to ensure the smooth flow of straigth-through traffic and to process right-turning traffic more efficiently.

- o Exclusive right-turn lanes will be provided with right-turn pockets.
- o Right-turn pockets will be constructed either by cutting off the median and allotting the resulting space to the pocket or, where there is no median, by shifting the center line to the lane in the opposite direction.

c) Improvement of Channelizing Islands

Improvements with respect to the locations and shapes of channelizing islands were reviewed for intersections which have a high volume of left-turning traffic and which require more than the current number of exclusive left-turn lanes, and for intersections where the line of movement of vehicles will be altered by a change in traffic regulations.

d) Improvement of Medians

In conjunction with changes in traffic regulation and the opening of new roads, medians that are located where traffic is to pass straigth through will be cut away.

e) Installation of Pedestrian Crossings

In conjunction with changes in traffic regulations, pedestrian crossings will be provided at intersections where the current one-way operation is to be altered to a two-way operation and where there is no pedestrian bridge nearby.

f) Improvement in Conjunction with Introduction of Reversible Lanes

Pavement markings and signs will be improved as necessary for reversible lane operation.

Of the 253 intersections subject to control by the ATC System, 91 require one or more of the improvements described above. These intersections are shown in Fig. 6.2.1. The improvements required at each intersection are listed in Table 6.2.2.

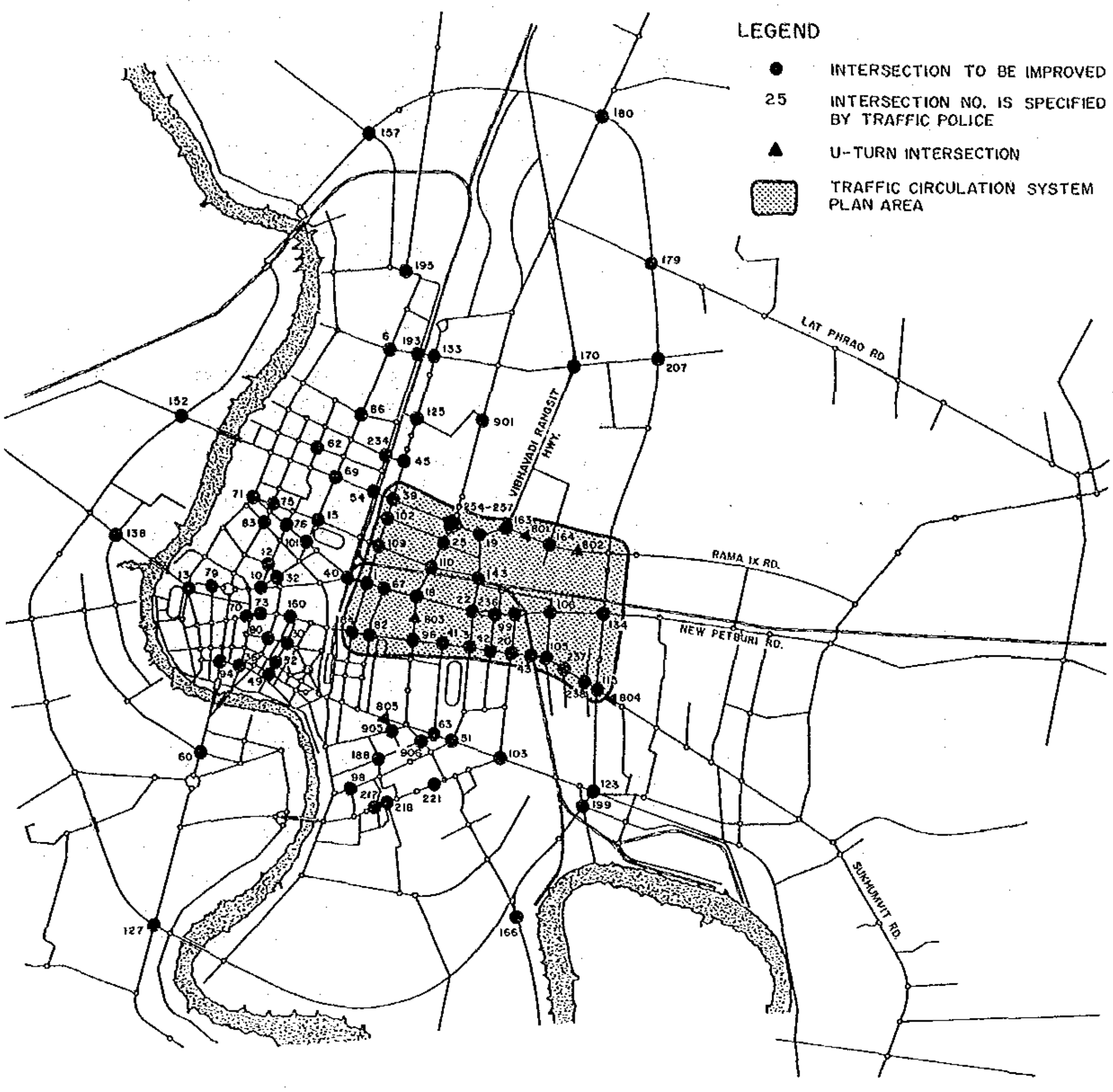


Fig. 6.2.1 Intersection to be Improved

Table 6.2.2(1) Improvement Measures by Intersection

Int. No.	1)Type	Approach	Main Projects I	II	III	2) Improvement Measures 1	2	3	4	5	6	3) Remark
1	K	4	*			o		o		o		Change to Two-Way
3	K	4	*		*	o		o			o	Reversible Lane
6	B	4				o	o					
10	K	6							o			
12	A	4							o			
13	K	5			*		o		o			
15	K	4				o						
18	K	4	*		*	o						Change to Two-Way, Flyover
19	K	3	*		*		o		o		o	Reversible Lane, Flyover(Plan)
20	K	4	*		*	o	o	o			o	Reversible Lane
22	K	4	*		*	o	o		o		o	Reversible Lane, Flyover
25	B	4	*			o	o			o		
30	C	4				o						One-Way
32	B	4				o						
36	K	4				o						One-Way
39	A	4	*		*	o	o					Change to Two-Way
40	K	4				o	o		o			Ramp(Plan), Flyover
41	A	3	*			o						Change to Two-Way
42	B	4	*			o		o			o	
43	K	4	*			o					o	Reversible Lane, Ramp
45	B	3								o		
49	B	4				o						One-Way
51	K	4			*	o	o					Elevated Road(Plan)
52	B	4					o					
54	B	4				o						One-Way
60	B	4					o		o			
62	B	4				o						
63	A	4			*		o					Elevated Road(Plan)
67	B	3	*			o		o				Change to Two-Way
69	K	4				o						
70	B	4				o						One-Way
71	B	5				o						One-Way
73	B	4				o	o					One-Way
75	B	4				o						One-Way
76	A	4				o						
79	B	4				o						
80	B	4				o						
82	B	4	*			o	o	o				Change to Two-Way

Note : 1) Int No.: Intersection No. is specified by Traffic Police
: 2) Main Projects
I : Traffic Ciculation System Plan
II : Planned Signalized Intersection
III : Right-turn Traffic-actuated Control
: 3) Improvement Measures
1 : Road Marking
2 : Exclucive Right-turn Lane
3 : Installation of Pedestrian Crossing
4 : Improvement of Channelizing Island
5 : Improvement of Median
6 : Improvement in Conjunction with Introduction of Reversible Lanes

Table 6.2.2(2) Improvement Measures by Intersection

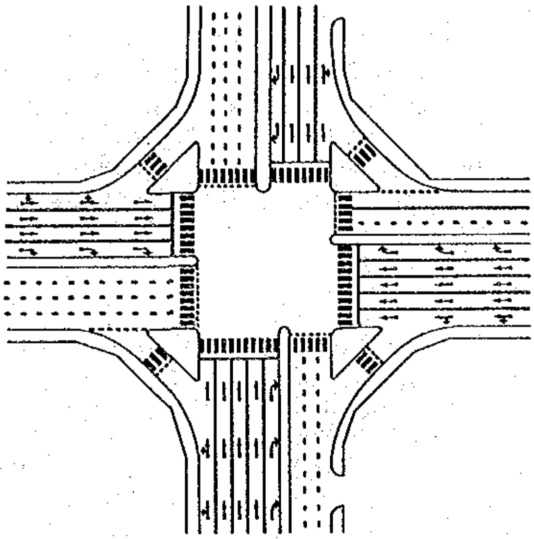
Int. No.	1)Type	App-roach	Main Projects I	II	III	2) Improvement Measures 1	2	3	4	5	6	3) Remark
83	C	6				o						One-Way
86	C	4				o						
94	A	4				o						One-Way
96	K	4	*		*	o		o				Change to Two-Way
98	B	4				o						
99	K	5	*		*	o		o				Reversible Lane
101	B	6					o					
102	B	3	*			o	o	o				Change to Two-Way
103	K	4			*	o						Flyover
105	K	4	*			o		o			o	Reversible Lane
106	K	4	*			o	o	o				Change to Two-Way
109	K	4	*		*	o						Change to Two-Way
110	K	4	*		*	o						Change to Two-Way
115	K	4	*		*	o	o	o			o	Reversible Lane, Elevated Road(Plan)
123	K	4			*	o			o			Flyover(Plan)
125	B	4				o		o				
127	K	4			*	o						
133	B	4			*		o					
134	K	4	*		*	o	o					Flyover, Elevated Road(Plan)
136	A	4			*	o						
143	K	5	*			o	o	o	o		o	Reversible Lane
145	K	4			*	o						
152	K	4			*	o						
157	A	4				o						Viaduct(Plan)
160	C	3				o						One-Way
163	K	4	*						o	o	o	Reversible Lane, Underpass(Plan)
164	B	4	*			o						
166	K	3					o					
170	K	4			*	o						Flyover
179	K	4			*	o						Flyover(Plan)
180	K	4			*	o						Flyover(Plan)
184	C	4	*			o	o	o				Change to Two-Way
188	C	4				o						One-Way
193	A	4					o					
195	A	6			*	o						
199	A	5				o	o	o				
207	B	4					o					
217	B	3				o						
218	B	4				o						
221	B	3				o						
234	B	5				o						Rail-Crossing
236	B	4	*			o		o	o	o	o	Reversible Lane
237	B	4	*			o		o			o	Reversible Lane
238	B	3	*			o		o			o	Reversible Lane
254-257	K	4	*			o			o			Ramp(Plan)
801	U	3		*						o		
802	U	3		*		o	o	o				
803	U	2	*	*		o	o	o				
804	U	2		*		o	o	o				
805	U	2		*		o	o	o				
901	B	3		*		o						
905	C	3		*		o						
906	C	4		*		o		o				New Road

4) Standard Intersection Layout

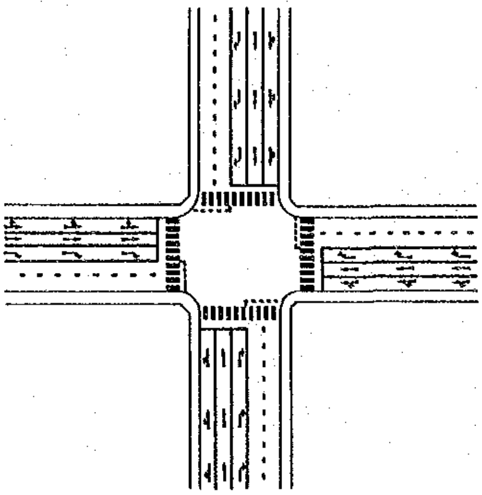
The subject intersections are divided into the five types shown below. The standard layout of each type is shown in Fig. 6.2.2.

Table 6.2.3 Intersection Types

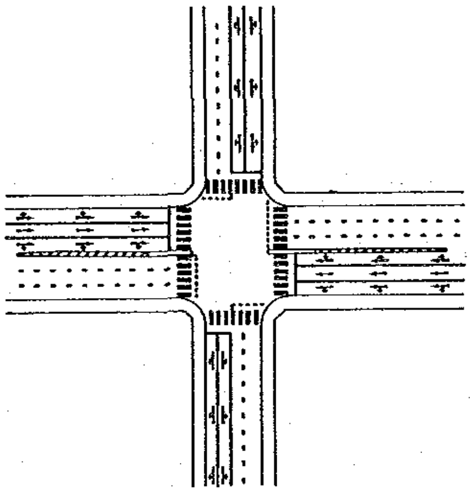
Type	Major Approach	Minor Approach
K	Key intersection	
A	5 lanes or more	5 lanes or more
B	5 lanes or more	4 lanes or less
C	3-4 lanes	3-4 lanes
U	U-turn signal	



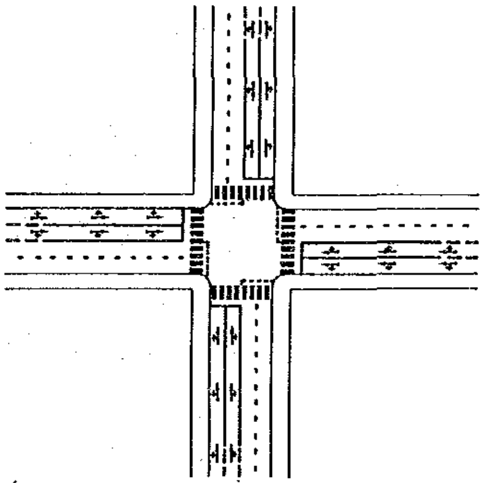
TYPE-K



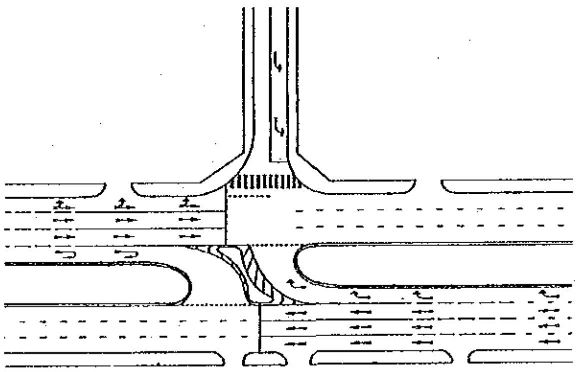
TYPE-A



TYPE-B



TYPE-C



TYPE-U

Fig. 6.2.2 Standard Typical Intersection

6.2.2 Reversible Lane Operation System

This section discusses the operating method for the reversible lane system called for in the Traffic Circulation Plan. At the same time, it plans for the traffic facilities that will be required to initiate the system. This plan is followed to the result of the Traffic Management Study for ATC System planning in Chapter 4.

1) Subject Road Sections

The subject road sections are the section between Ratchaprarop Rd and Vibhavadi Rangsit Rd on Din Daeng Rd (roughly 0.6 km), the section between Din Daeng Road and Petburi Road on Ratchaprarop Rd (roughly 1.4 km), the section between Ratchaprarop Rd and the ETA Expressway on Petburi Rd (roughly 0.9 km), and the section between Ratchaprarop Rd and the Middle Ring Road on Sukhumvit Rd (roughly 2.5 km). These sections are shown in Fig. 6.2.3.

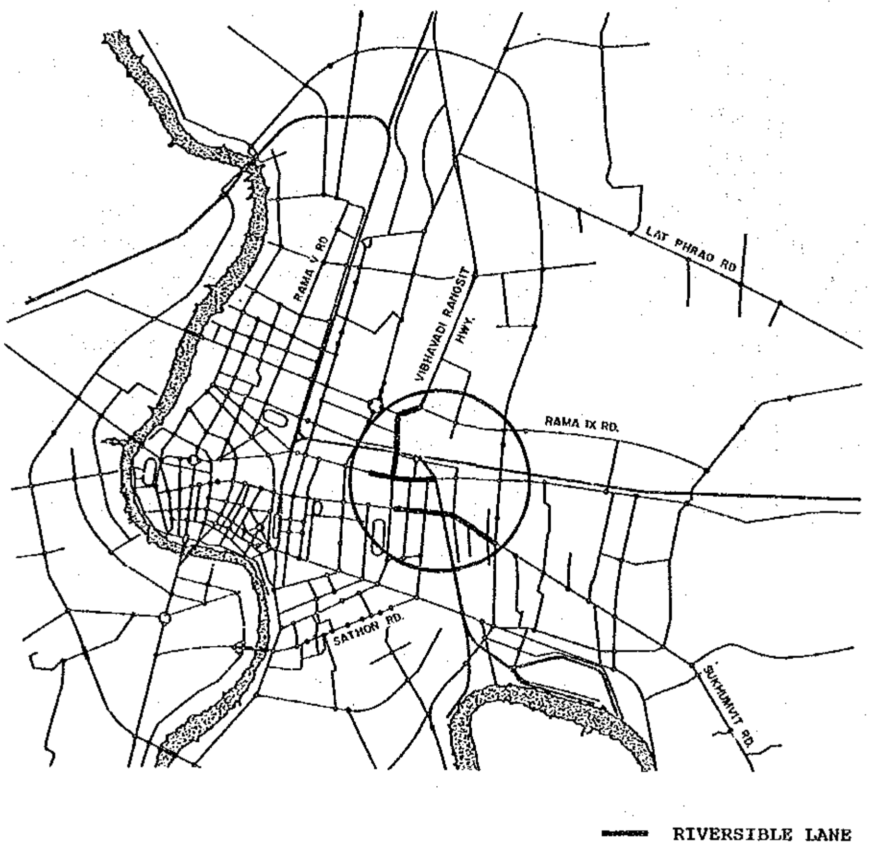


Fig. 6.2.3 Locations of Reversible Lane

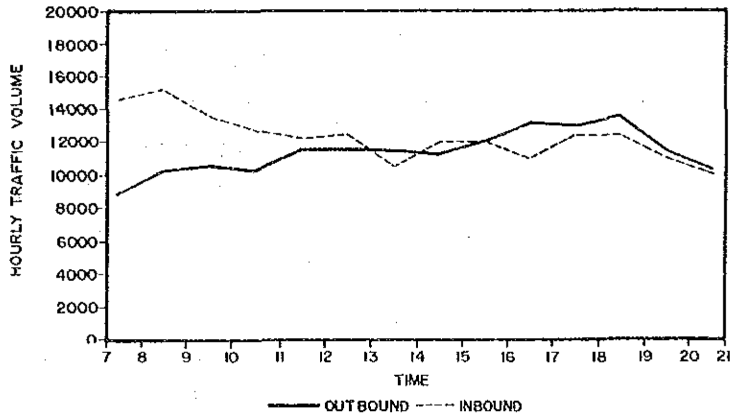
2) Plan Outline

a) Operating Method

o Time Periods for Reversible Lane

As a general rule, time periods for reversible lanes were established so that priority is given to inbound traffic during the morning hours when commuter traffic is heavy and to outbound traffic during the afternoon hours. Accordingly, priority is given to inbound traffic between 6:00 and 11:00, and priority is given to outbound traffic after 11:00.

These time periods were established on the basis of the time periods currently applied to existing reversible lanes in Bangkok city, as well as on the survey results given in Fig. 6.2.4. From the results of the investigation of the hourly fluctuations of the combined cross section traffic volume on Din Daeng Rd, Petburi Rd, Sukhumvit Rd, and Rama IV Rd, which are major east-west traffic, by inbound and outbound traffic, the benefical effects of the time of changing the reversible lane can be seen around 11 a.m.



NOTE : EAST-WEST MAJOR ROADS .... DIN DAENG RD., PETBURI RD., SUKHUMVIT RD. & RAMA IV RD.

SOURCE : SIMR 1989

Fig. 6.2.4 Hourly Fluctuation of Combined Cross Section Volume o Traffic Operation Method

Reversible lanes will be implemented in the presence of a traffic police. Reversible lane usage will be notified to drivers by overhead lane direction signals and signs (gantry and pedestrian bridge), variations in lane line color, and lane-use designators (the temporary sign used currently by the Police). As a general rule, overhead lane direction signals will be provided at the starting and ending points of reversible lanes, and, in between these points, overhead lane direction signs will be attached to existing pedestrian bridges. The use of pedestrian bridges will reduce the cost of overhead lane direction signals. At intersections, reversible lane usage will be notified by variations in lane line color and by lane-user designators. In areas outside the reversible lane section, guide signs will be installed 150-200 meters upstream from the starting point in order to warn drivers.

In reversible lane sections, parking and diverging right-turning movement onto side roads will be restricted. Converging right-turning movement at nonsignalized intersections will also be restricted.

Standard traffic operation methods to be applied to intersections and other road sections are shown in Fig. 6.2.5.

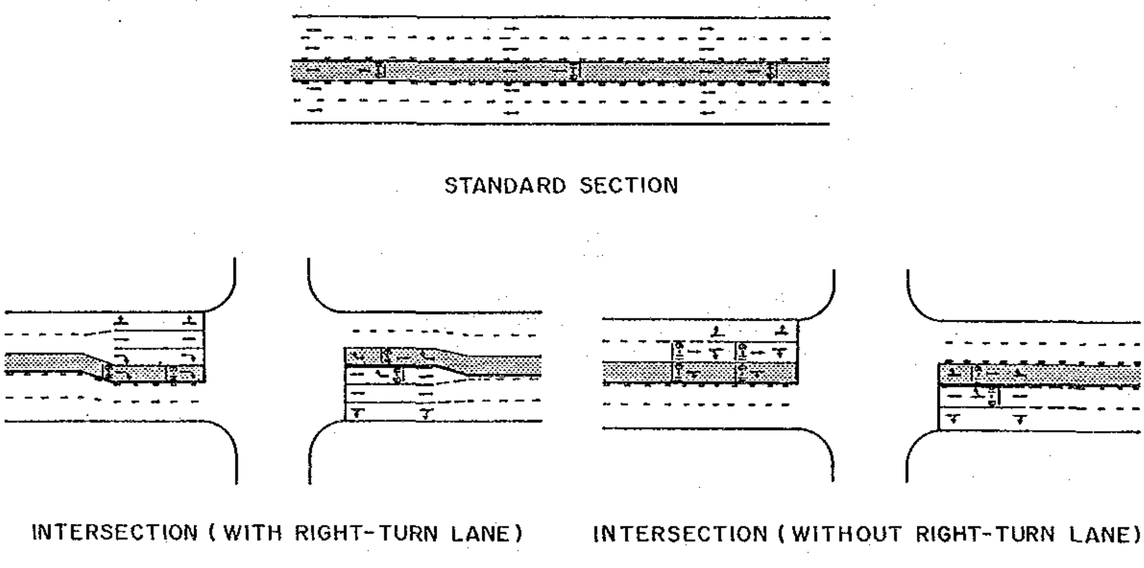


Fig. 6.2.5 Standard Traffic Operation Method

b) Traffic Facilities Plan

The planned locations of traffic facilities are shown by subject route in Fig. 6.2.6.

Standard designs of traffic facilities required for reversible lane operation are shown in Fig. 6.2.7. The quantities of such traffic facilities are shown by subject route in Table 6.2.4.

Table 6.2.4 Traffic Facilities to be Installed

Road	Overhead Type Traffic Signal Head (Gantry)	Direction Sign for Lane (Pedestrian Bridge)	Traffic Sign for Designating of Center Line	Guide Sign	Road Marking (m^2)
DIN DAENG	19(2)	9	2	4	160
PETBURI	16(2)	26	4	6	570
RATCHAPRAROP	11(4)	24	2	7	300
SUKHUMVIT	17(2)	48	2	14	560

( );Number of Gantry

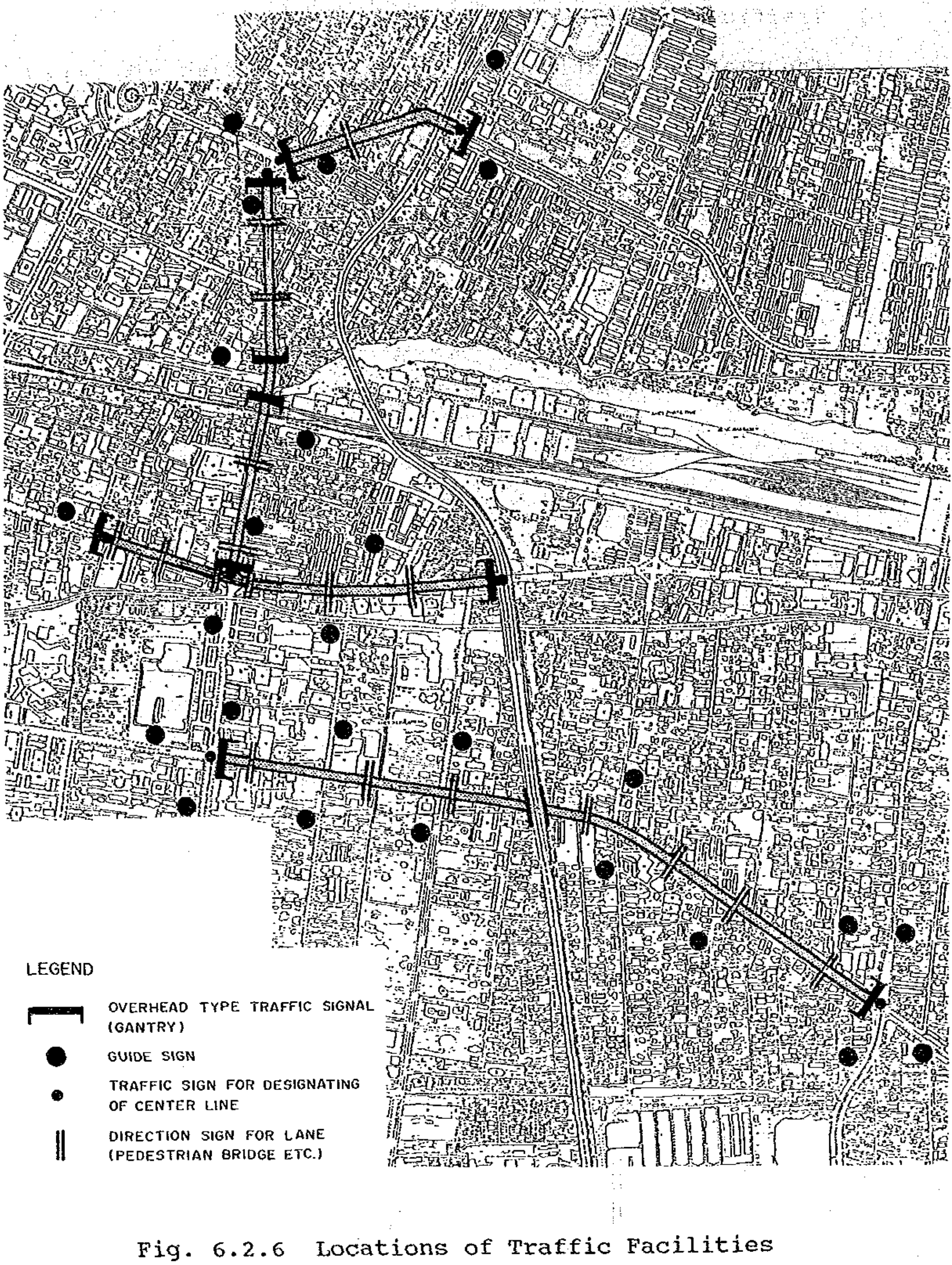
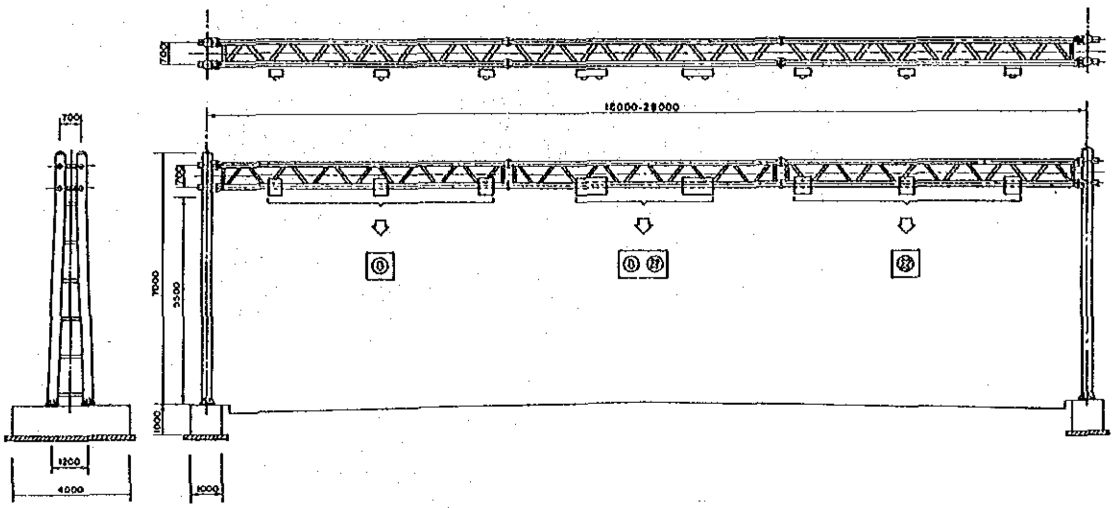
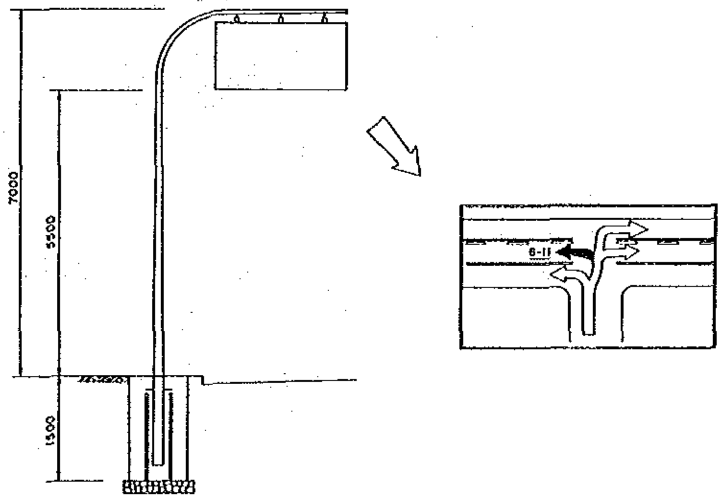


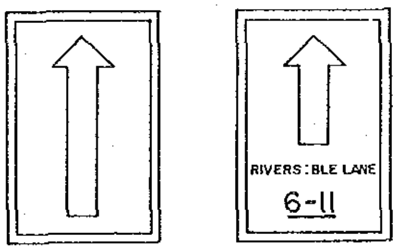
Fig. 6.2.6 Locations of Traffic Facilities



GANTRY

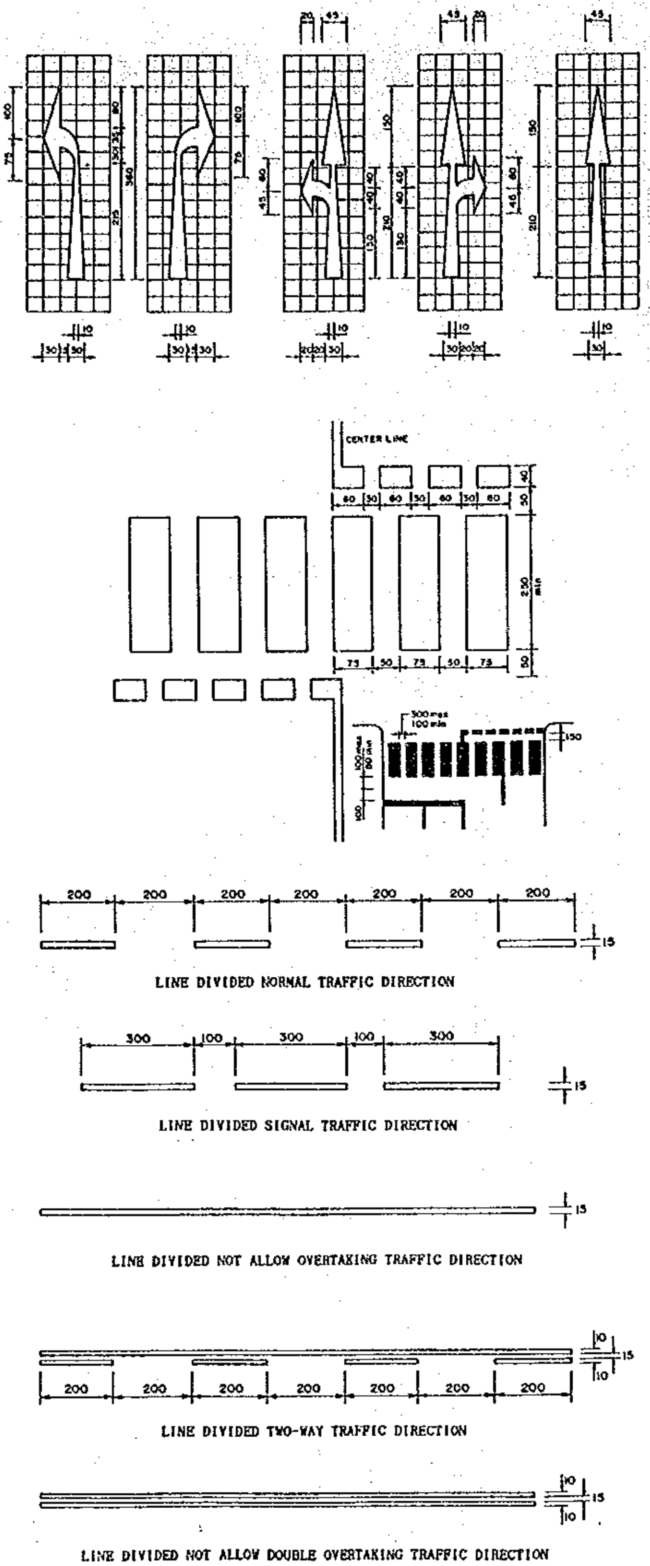


GUIDE SIGN (SIGNALIZED INTERSECTION)



DIRECTON SIGN

Fig. 6.2.7(1) Standard Traffic Facilities



ROAD MARKING SOURCE : BMA

Fig. 6.2.7(2) Standard Traffic Facilities

6.3 Vehicle Detectors

6.3.1 Functions of Vehicle Detectors

Vehicle detectors (hereinafter referred to as detectors) fulfill various functions related to signal control, including those described below, by detecting the presence of motor vehicles for the collection of traffic data.

1) Detectors for Coordinated Area Control (used to determine cycle length and offset)

Based on data collected from detectors, the cycle length and offset pattern for a given subarea, which is made up of a number of signalized intersections, are either selected from control plans prepared in advance or individually calculated, and then applied to the subarea. All signals in the subarea thus have the same cycle length and the appropriate offset. The selection procedure is described in Chapter 5.

In the same way, offsets at intersections which are located at the boundaries of two subareas (included in each sub-area) can be adjusted if the two subareas have the same cycle length. In this way, signal control within the entire area is coordinated.

2) Detectors for Split Control

Split, in other words the green time allotted to each direction at a signalized (key) intersection, is calculated on the basis of data transmitted by detectors. Data from detectors in this case are processed to indicate the saturation rate of traffic flow in each direction.

3) Detectors for Vehicle Actuated Control

Intersection throughput can be increased by extending the green time of a given direction. Demand volume in this case is obtained from detector signals transmitted by the detector(s) located on the lane subject. Vehicle actuated control includes semi-actuated, full-actuated, right-turn control and flow-rate actuated systems.

4) Detectors for Congestion Indication

Traffic information such as queue length indicated on the wallmap display is supplied by detectors via the computer.

5) Detectors for Compiling Traffic Statistics

Locations on which traffic data are needed for statistical purposes are provided with detectors. Data obtained from these detectors are used to formulate plans for planned signal installations and to improve existing control plans.

6.3.2 Standard Location Plan of Vehicle Detectors

The locations of detectors will be as follows in accordance with section 5.3.2 (Basic Control Methods).

1) Location of Detectors for Coordination, Split Control and Flow-rate Actuated Control

Detectors for coordination, split control and flow rate-responsive control will be placed at key intersections of subareas (Fig. 6.3.1). The standard location plan of these detectors is shown in Fig. 6.3.2.

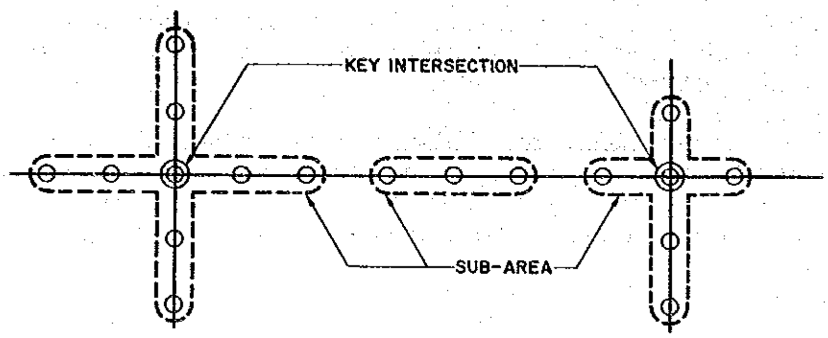


Fig. 6.3.1 Key Intersection and Sub-area

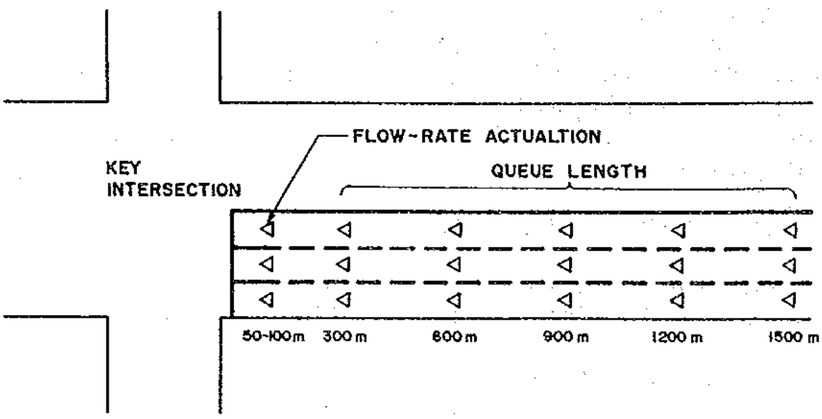


Fig. 6.3.2 Location of Detectors for an Approach of Key Intersection

2) Location of Detectors for Right-Turn Actuation

Detectors for right-turn actuation will be placed on exclusive right-turn lanes. The standard location plan of these detectors is shown in Fig. 6.3.3.

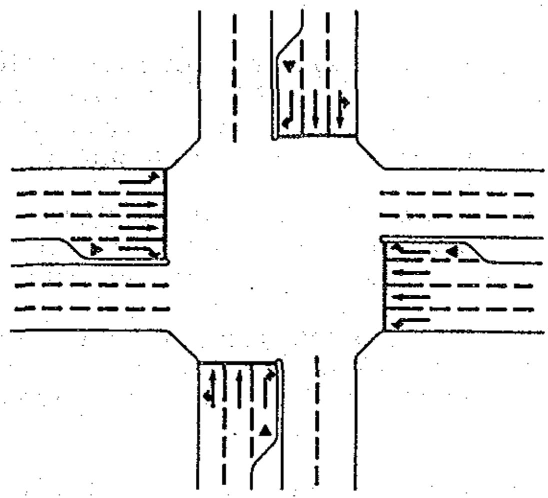


Fig. 6.3.3 Location of Detectors for Right-turn Actuation

3) Location of Detectors for Obtaining Traffic Statistics

The standard locations plan of detectors for obtaining traffic statistics is shown in Fig. 6.3.4.

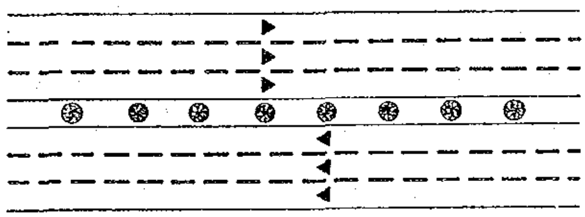


Fig. 6.3.4 Location of Detectors for Statistic Use

6.3.3 Actual Location Plan of Vehicle Detectors

Although it would be ideal if the detectors could be placed in accordance with the standard location scheme, it is impractical to do so owing to cost and locational considerations. Therefore, a location scheme that requires less cost but does not undermine the functions of the ATC System was reviewed in accordance with the following procedure.

1) Detectors required for the various functions were installed on the road network in the ATC System Area. If two or more detectors for different functions were assigned to the same location, these were combined into one detector.

2) Detectors for congestion indication were omitted from locations where the current queue length is not expected to increase, as indicated by simulations and other methods.

3) Where detectors for congestion indication were planned to be installed on more than one lane at a given location, detectors other than the one on the representative lane were omitted.

4) Of the detectors for right-turn actuation that actuate the same signal stage but for different approaches, those on approaches with heavy traffic volumes were reduced.

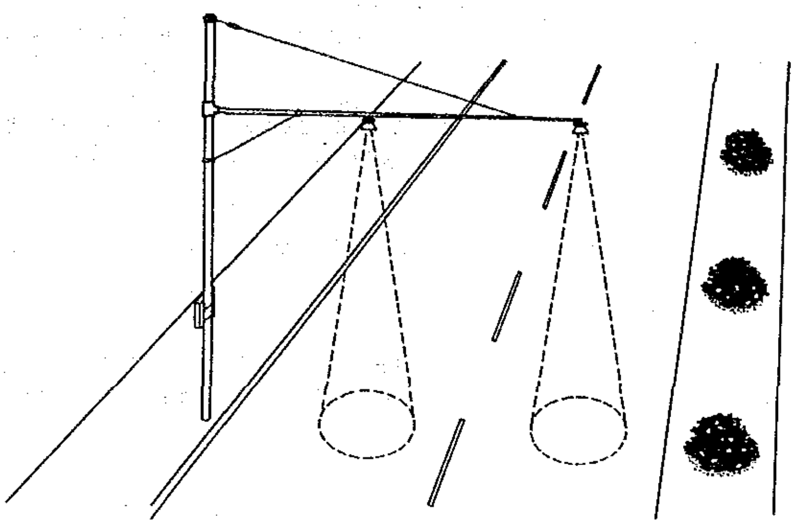
The number of detectors required for the entire ATC System Area is 423 units (not locations). Table 6.3.1 gives a breakdown of this number by function.

Table 6.3.1 Number of Detector Units by Functions

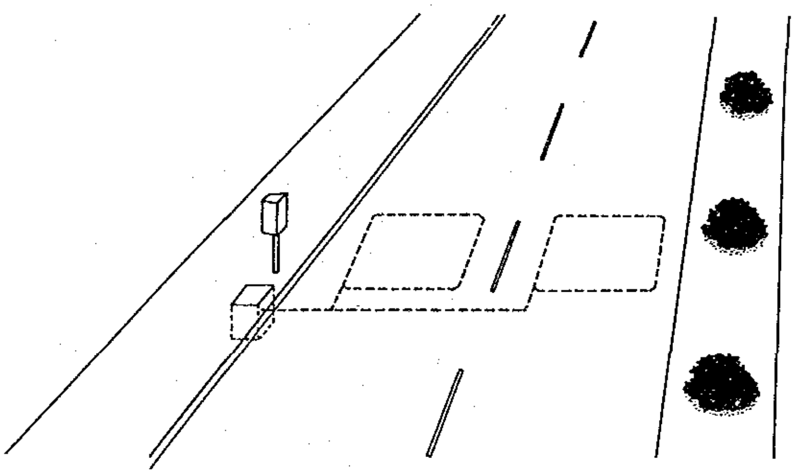
Functions	Detector Units
-Coordinated Area Control & Split Control	296
-Vehicle Actuated Control	72
-Congestion Indication	10
-Compiling Traffic Statistics	45
Total	423

6.3.4 Types of Vehicle Detectors

Two types of detectors were considered: Inductive loop detectors (hereinafter called loop detectors) and ultrasonic detectors. Both are stable in performance and reasonable in price, and are used widely for these reasons. Fig. 6.3.5 shows the various types of detectors.



ULTRA SONIC TYPE



LOP TYPE

Fig. 6.3.5 Types of Vehicle Detector

Selection between loop and ultrasonic detectors was determined by taking into consideration the advantages of each and the special characteristics of the location.

1) Ultrasonic detectors were chosen as a general rule. This is because:

   a) In the fast-growing city of Bangkok, excavation works (for underground utility installations) occur frequently, and, if loop detectors are used, their loop coil feeder lines can be severed time and again in the process of such works.

   b) Ultrasonic detectors require less time to install, which means that traffic restrictions need to be imposed only for a short time.

2) Loop detectors were allotted to the following locations:

   a) Scenic Streets

   Loop detectors were allotted to streets whose scenic beauty must be preserved. These streets are shown in Fig. 6.3.6.

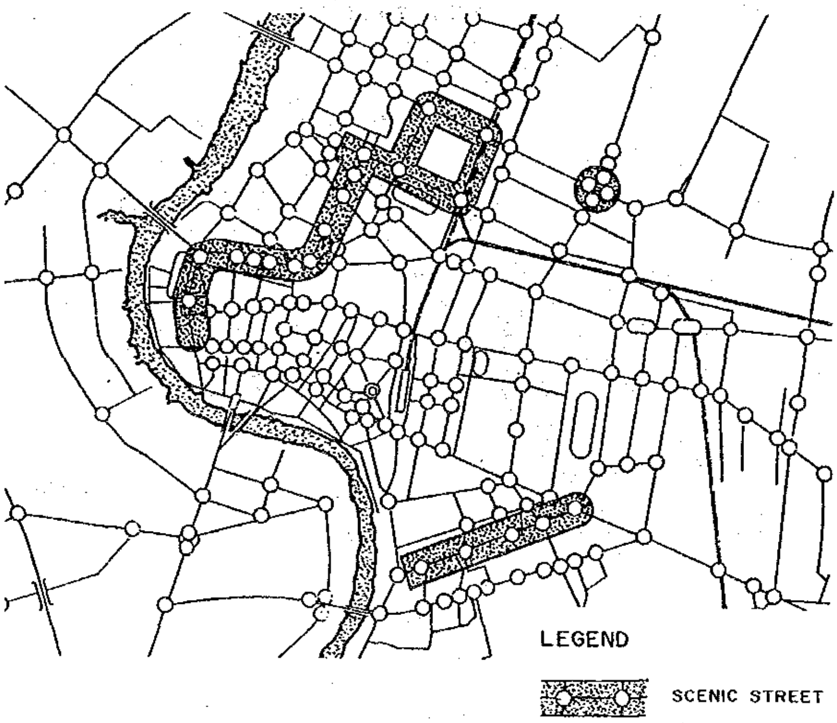


Fig. 6.3.6 Scenic Street

b) Wide Streets

To use an ultrasonic detector, it is necessary to extend a boom (or arm) from the side of the roadway and attach a transducer above the carriageway. Since the boom is long enough to cover only three lanes, loop detectors were allotted to streets with four or more lanes in each direction. However, wherever there is a pedestrian bridge that can serve in place of the boom, an ultrasonic detector was allotted.

c) Tree-Lined Streets

Since the presence of branches and leaves causes ultrasonic wave beams to bounce erratically, destabilizing the performance of ultrasonic detectors, loop detectors were allotted to tree-lined streets with a thick cover of branches and leaves (over the carriageway).

As a result of the above considerations, the numbers of loop and ultrasonic detector units were determined to be as shown in Table 6.3.2.

Table 6.3.2 Number of Detector by Type

Functions	Loop	Ultra-sonic
-Coordinated Area Control & Split Control	32	264
-Vehicle Actuated Control	42	30
-Congestion Indication	0	10
-Compiling Traffic Statistics	0	45
Sub-Total	74	349
Total	423	

6.3.5 Concentration of Detector Pulses

Detector pulses from detectors are transmitted to the ATC Center (computer). To reduce the number of transmitting lines that must be borrowed from the TOT, local controllers equipped with transmitters collect the pulses emitted by a number of nearby detectors and transmit the pulses to the central computer.

For this purpose, taking into account the cost of leasing lines from the TOT, detectors located within 300 meters from an intersection are basically connected by cables to the local controller at the intersection. Considering the locations of the detectors, transmitters built into local controllers must have the capacity to handle information received from 16 detector units.

Concerning detectors located over 300 meters from an intersection, one of these dectors is equipped with a transmitter and connected to a nearby detector (which is also located over 300 meters from the intersection).

Fig. 6.3.7 shows a typical plan for concentrating detector pulses.

Connecting cables are placed aerially using MEA or TOT poles. However, if this is not possible, the cables are installed below the sidewalk.

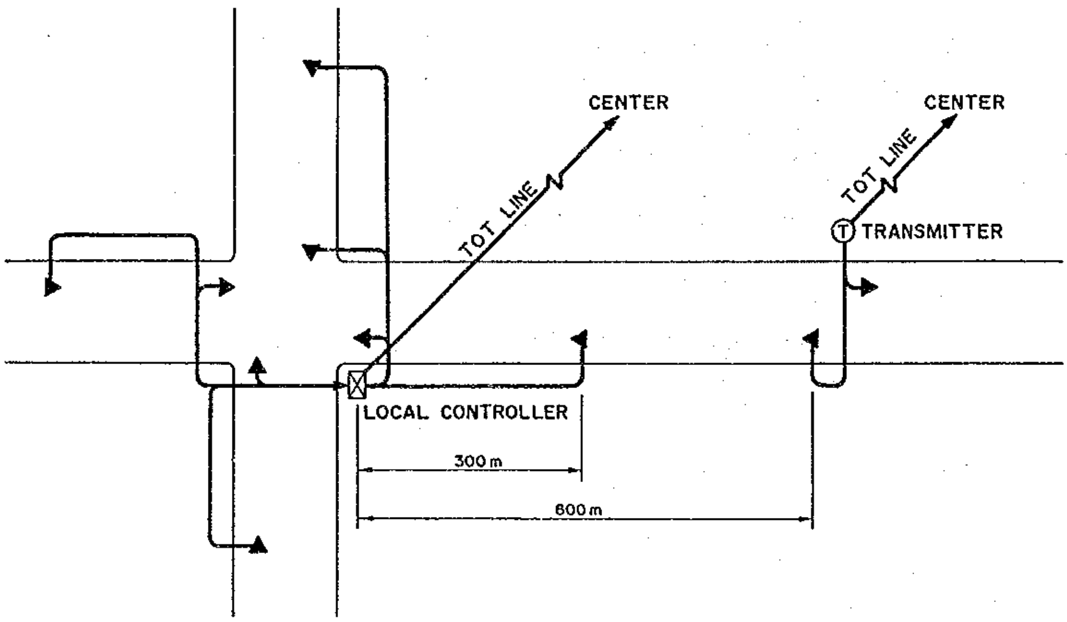


Fig. 6.3.7 Detector Pulses Concentrating Plan

6.3.6 Standard Installation Plan

The standard installation plan for detectors is shown in Fig. 6.3.8.

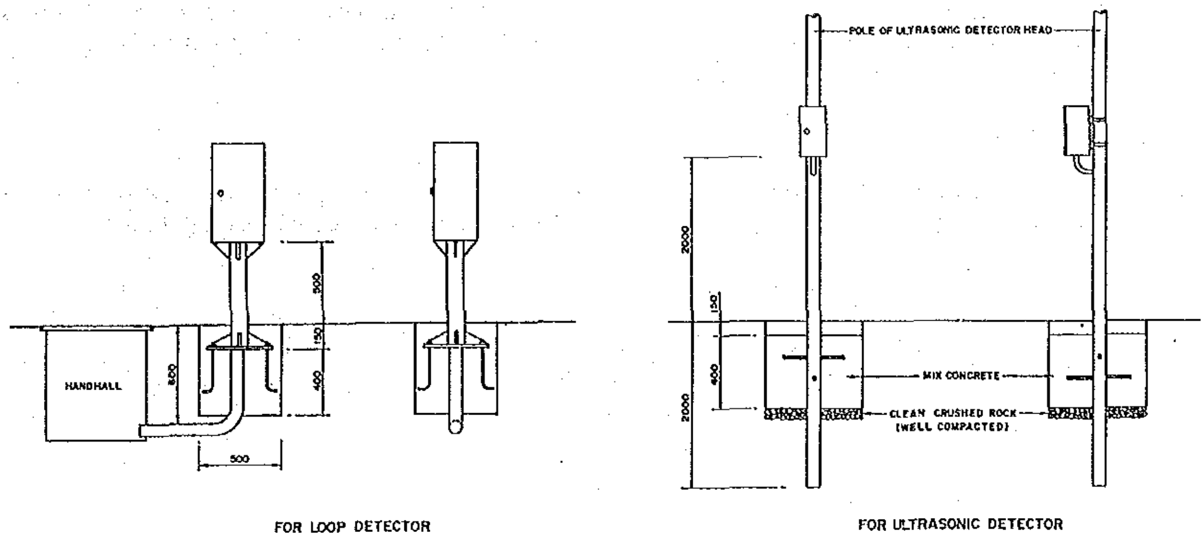


Fig. 6.3.8 Standard Installation Plan for Detector Cabinet

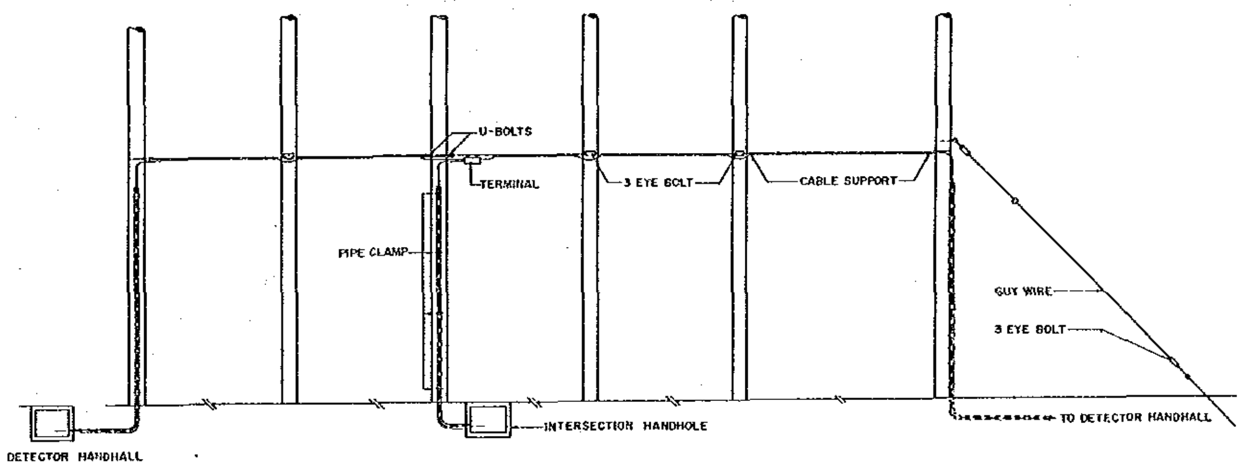


Fig. 6.3.9 Aerial Cable

6.4 Local Controllers

6.4.1 Functions of Local Controllers

Local controllers share functions with the central computer, including the control logic discussed in Chapter 5, and fulfill the functions described below. The functions of the terminal transmitters with which local controllers are equipped are described in a later section.

1) On-Line Control

On-line control of traffic signals based on real-time conversions of control plans as they are sent from the central computer

2) Vehicle Actuated Control

   a) Flow-rate actuated control
   b) Right-turn actuated control

3) Backup

   a) Time-of-day control
   b) Flashing

4) Manual Control

Local controllers are designed under the assumption that the ATC System rarely requires manual control. Intentional intervention from the ATC Center takes the place of manual control.

6.4.2 Standard Installation Plan Near Intersections

1) Standard Equipment

Standard local controller-related equipment near intersections are as follows:

a) Renewal Equipment

   Existing local controllers are replaced with those for on-line control.

b) Retained Equipment

   The following equipment are retained:

   - Signal poles and lights
   - Handholes
   - Underground conduits

c) Additional Equipment

   The following equipment are newly added:

- o Where existing traffic lights have low visibility, lights mounted on tall poles are added.

- o Junction boxes are provided as demarcation points between BMA- and TOT-responsible areas.

d) Cables

In order to create more space in existing conduits so that detector cables can be laid, cables currently housed in the conduits are replaced with cables that contain more strands of wire (about 30). At the same time, relay terminals are provided in order to have cables for traffic signals branch off.

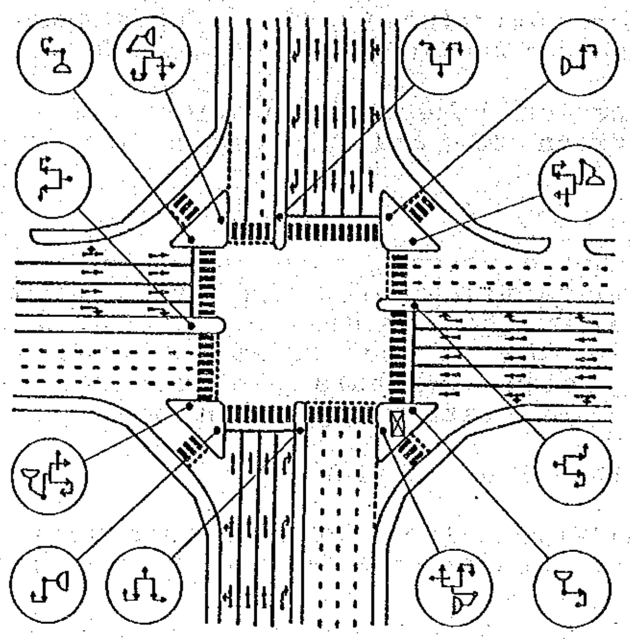
2) Standard Installation Plan

Standard installation plans for equipment near intersections are shown by type of intersection in Figs. 6.4.1(1)-(3).

There are six types of intersection, as given in Table 6.4.1. Of these, Types U and the ETA Ramp Junction are new intersections. Type U applies to locations where the medium is to be cut open and U-turn signals installed for the purpose of shortening trip length and reducing congestion at nearby key intersections. ETA Ramp Junction applies to ETA Second Stage Expressway ramp junctions where traffic signals are to be installed for the purpose of ensuring the smooth and safe flow of vehicles entering and leaving the ramps.

Table 6.4.1 Classification of Signalized Intersection

Type	Major Approach	Minor Approach	Remark
K	Key intersection		
A	5 lanes or more	5 lanes or more	
B	5 lanes or more	4 lanes or less	
C	4 lanes or less	4 lanes or less	
U	U-turn signal		New
ETA	ETA ramp junction		ETA Second Stage Expressway; new



TYPE-K

SYMBOLS FOR ASPECTS

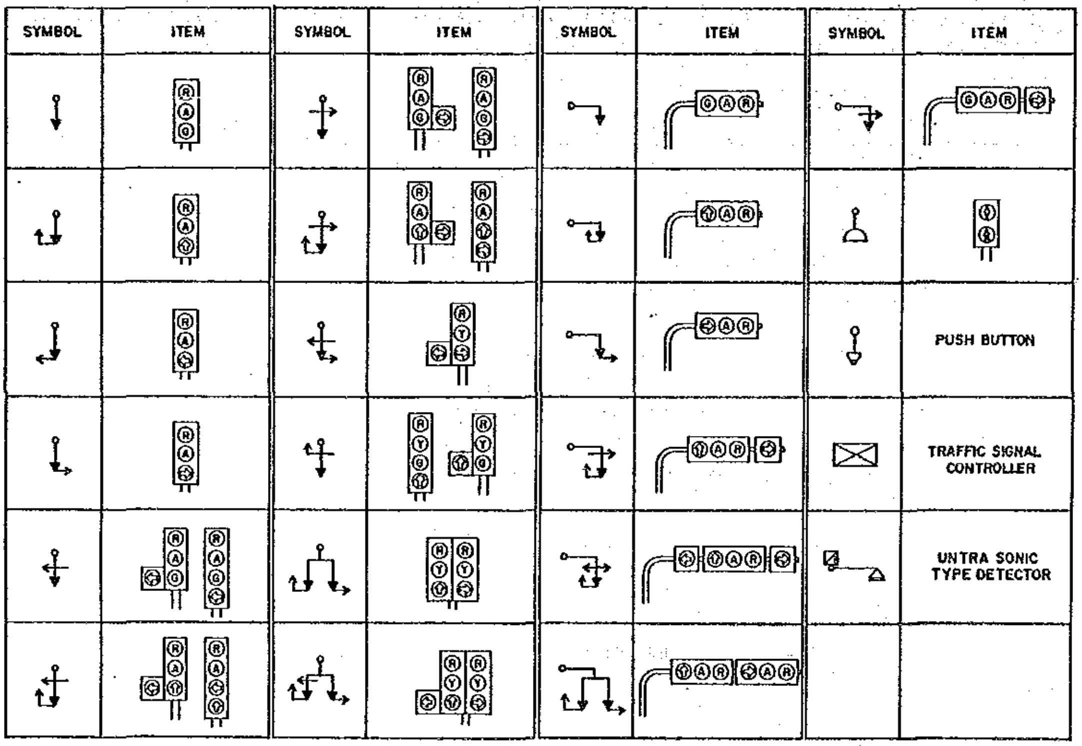
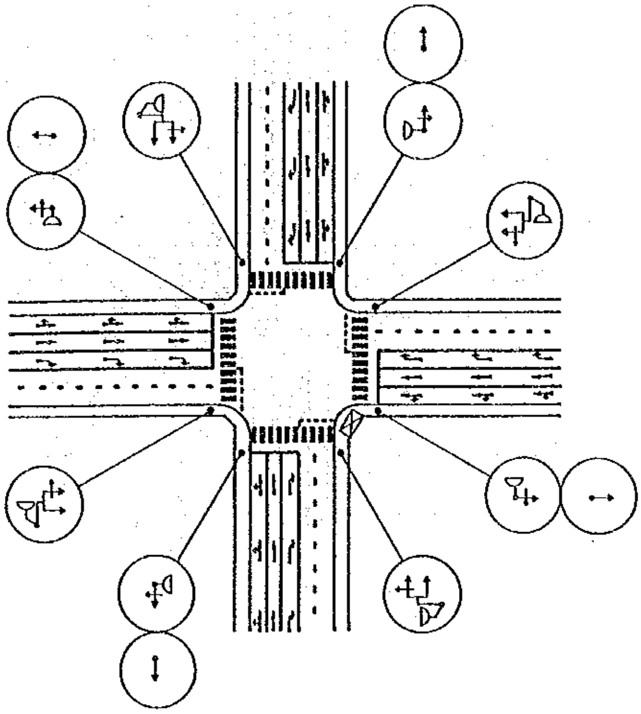
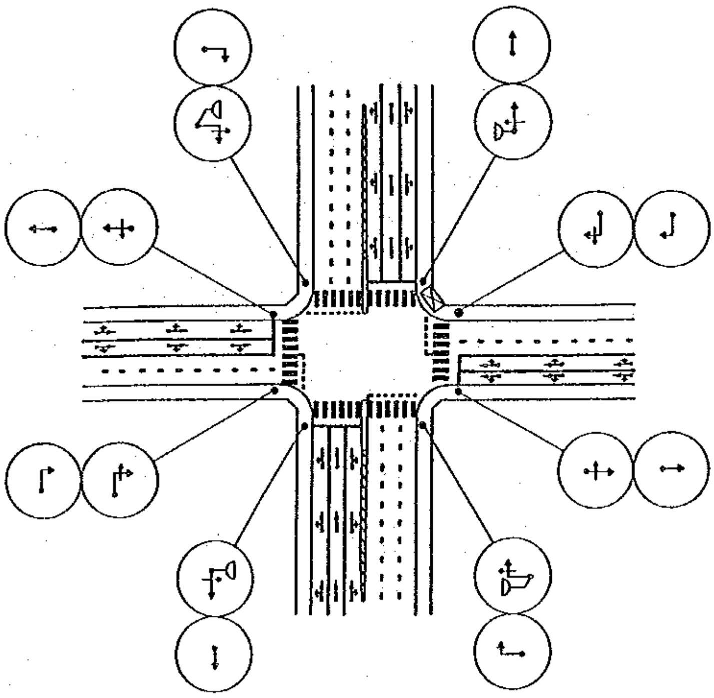


Fig. 6.4.1(1) Standard Installation Plan Around Intersection

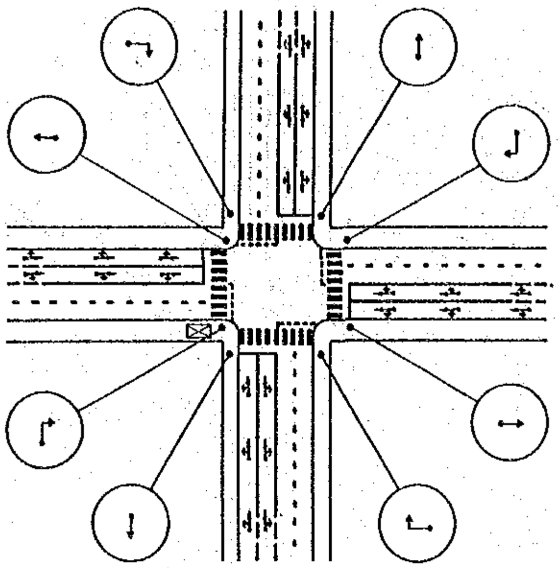


TYPE-A

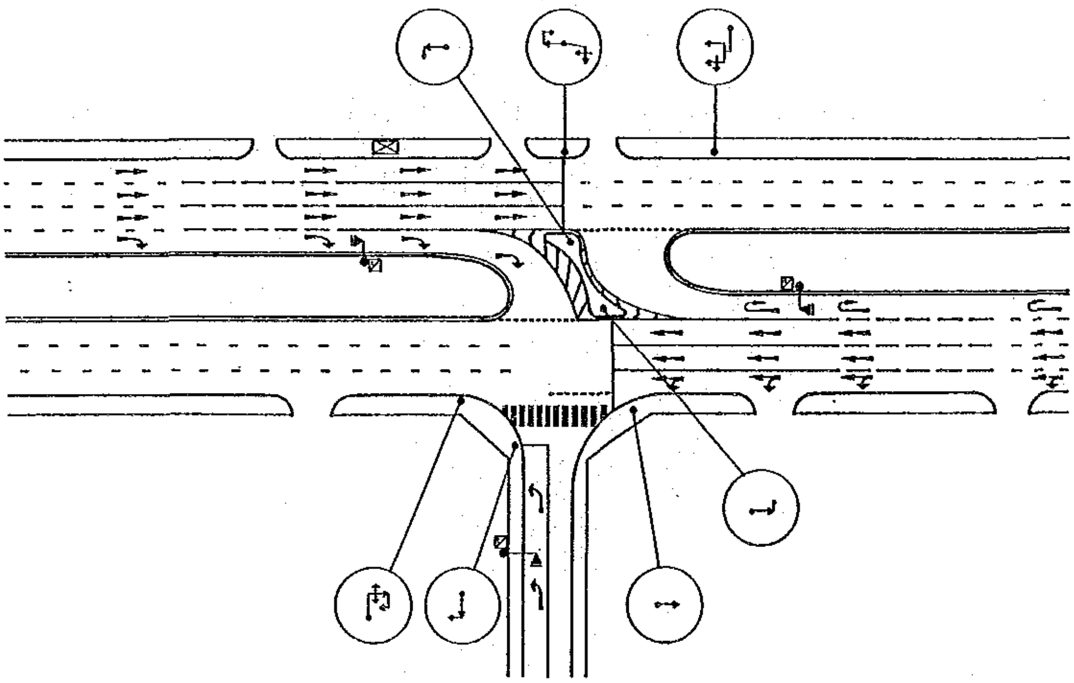


TYPE-B

Fig. 6.4.1(2) Standard Installation Plan Around Intersection

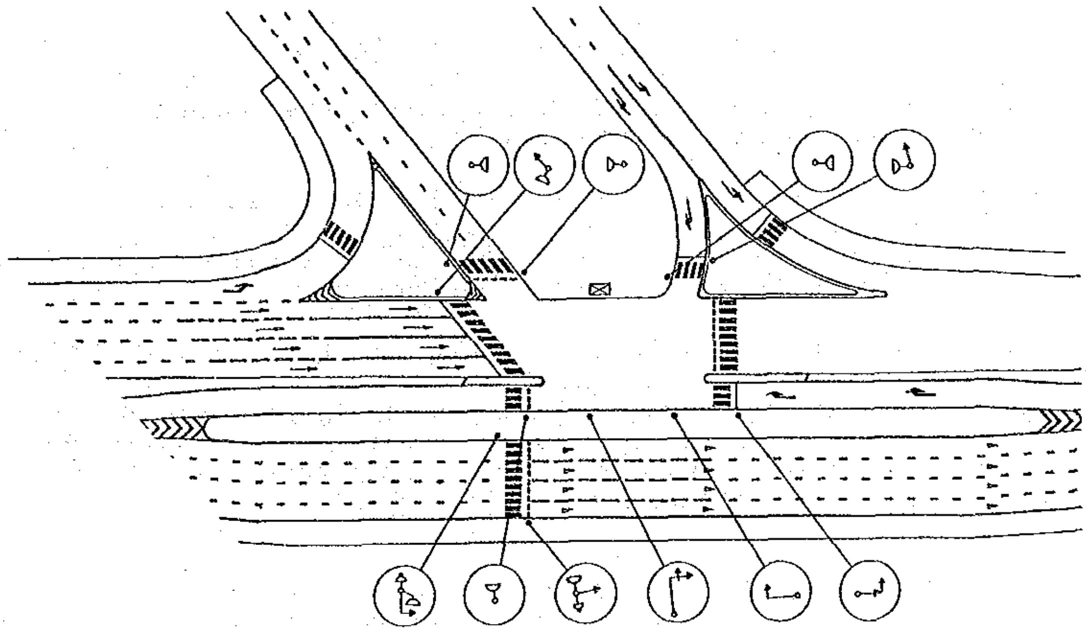


TYPE-C



TYPE - U

Fig. 6.4.1(3) Standard Installation Plan Around Intersection



TYPE-ETA

Fig. 6.4.1(4) Standard Installation Plan Around Intersection

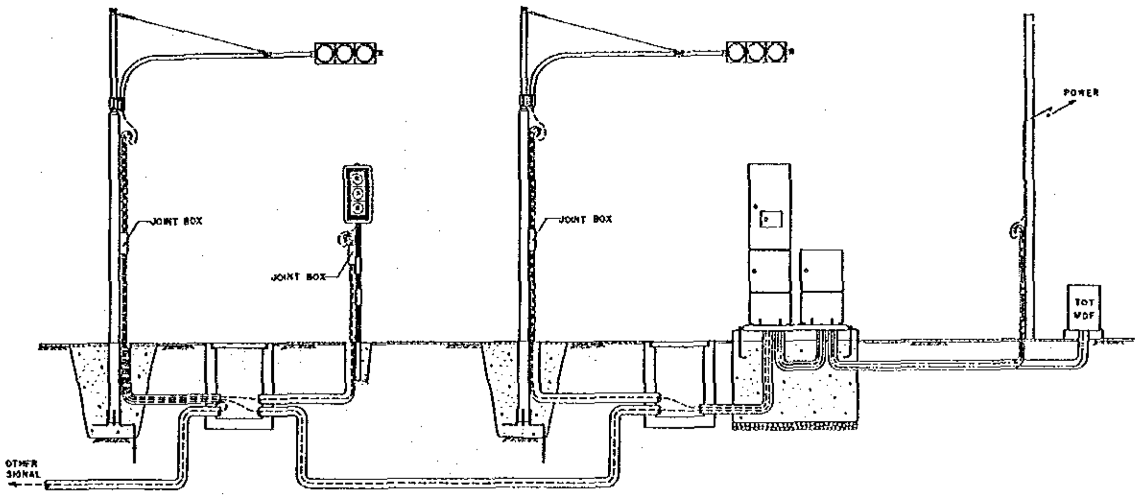


Fig. 6.4.2 Installation Plan of Intersection

6.5 Communication Network and Transmission System

6.5.1 Critical Demand for Data Transmission

There are four directions in which data are transmitted from transmitting equipment to equipment:

- o Center ----------------------> Local controller
- o Local controller -----------> Center
- o Center ----------------------> Detector with transmitter
- o Detector with transmitter --> Center

Of these, the largest volume of data is transmitted from the local controller to the center. This is because local controllers transmit data obtained from a maximum of 16 detector units. Calculations indicate that the volume of data to be transmitted from a local controller is roughly 8,000 bits per signal cycle or so, as shown in Table 6.5.1.

Table 6.5.1 Data Transmission Volume from Local Controller to Center

Item	Volume
Detector data	About 2,700 bits
Local controller data	About 600 bits
Reserve and protocol control	About 4,700 bits
Total	About 8,000 bits

In a traffic-responsive system, it is vital that the above data be sent to the CPU, processed, returned, and reflected in signal control parameters and splits as quickly as possible.

6.5.2 Network Reliability

The TOT gives the following values as targets for line reliability:

80% recovery is expected in 24 hours.
99% recovery is expected in 7 days.

The communication network and backup system were considered under the above conditions.

6.5.3 Network Design

Based on transmission demand volume and line reliability as given conditions, the following network were selected for the ATC System in order to ensure the reliability of the System.

- o The TOT's pulse code modulation (PCM) network is leased as the System's exclusive line. In the network, stations are linked to each other by PCM, while subscriber terminals are linked to stations by metallic line.
- o 2-wire method is used.
- o Line configuration is 1:1.

Fig. 6.5.1 shows a rough plan of the communication network.

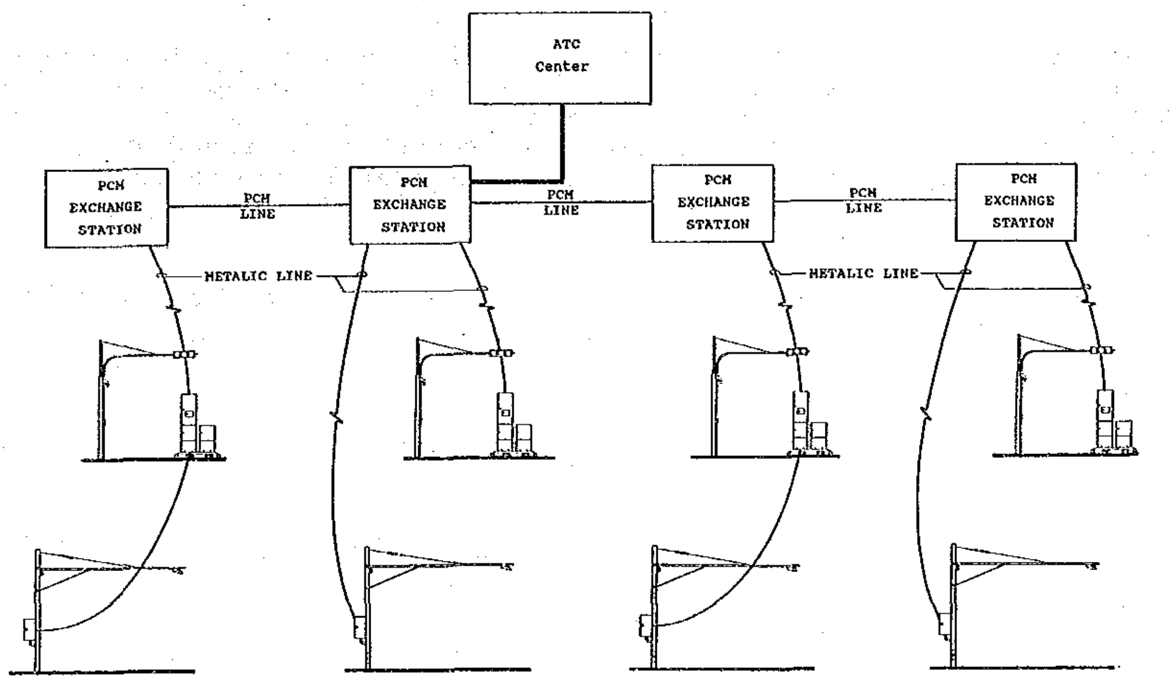


Fig. 6.5.1 Network Design

6.5.4 Transmission System and Equipment

1) Transmission System

The transmission system is as follows:

Line ----------------	2-wire, transparent through PCM
Communication mode --	Full-duplex
Modulation method ---	Frequency shift keying (FSK) or Phase shift keying (PSK)
Response mode -------	Synchronous response mode (SRM)
Protocol level ------	Data link level
Data length ---------	Variable data length

Concerning the modulation method, PSK is recommended because it uses a lower frequency than FSK, which means that the transmission of PCM signals is more efficient, and it is more resistant to noise. In addition, a transmission speed of 2,400 bps is recommended in order to increased overall throughput.

2) Transmission Equipment

The communication network is composed of the transmission equipment shown in Fig. 6.5.2.

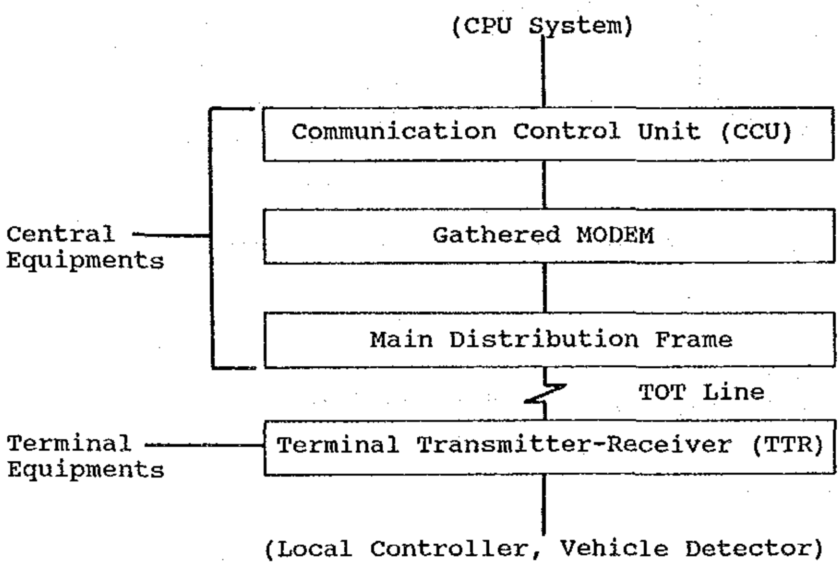


Fig. 6.5.2 Transmitting Equipments

The central equipment is designed with a capacity for 320 lines, but the actual number of lines is thought to be 235 lines for communication with local controllers and 35 lines for communication with detectors, or a total of 270 lines.

a) Communication Control Unit (CCU)

The CCU converts parallel mode data received from the Central Processing Unit (CPU) into serial mode data in accordance with the transmission procedure, and converts serial mode data received from terminals into parallel mode data, while checking for transmission errors at the same time, and relays the converted data to the CPU system.

b) Gathered Modems

Modems place serial signals generated by the CCU onto carrier waves in order to transmit the signals over long distances via the line. They also extract serial signals from carrier waves received from terminals and relay the signals to the CCU.

c) Main Distribution Frame (MDF)

The MDF serves to divide the central equipment line between TOT-responsible and BMA-responsible areas. The MDF is composed of relay terminals for exclusive lines and equips each line with a protective device (PD), test switching device, and arrester.

d) Terminal Transmitter-Receiver (TTR)

The TTR, a compact unit that combines the functions of the CCU and modem, is a transmission device for terminals. It is built into the cabinet of a local controller or detector.

6.6 Man-machine Interfaces

The ATC Center is to be established on the first floor of the building housing the Traffic Engineering Division of the BMA.

The ATC Center is composed of a control room and a computer room. Activities that take place in the control room include the receipt of traffic data from all over the ATC Area, decision-making concerning countermeasures appropriate to the situation at hand, instructions to related personnel, and notification of congestion information to drivers. All the various equipment which are used to obtain from the ATC System information useful to such activities and to operate the ATC System in order to implement countermeasures are called man-machine interfaces.

6.6.1 Display Equipment and Their Functions

Display equiment consist of a wallmap display and character CRT displays.

1) Wallmap Display

The wallmap display is used to show overall traffic conditions. Its panel size is roughly 6 meters high and 6 meters wide. A small scale is used to represent roads in the central area of the Bangkok Metropolitan Area, and a large scale is used to respresent those in the surrounding areas. The display panel is composed of mozaics including lamp indicators.

a) Lamp indicators show the following information:

- o Degree of congestion and queue length
- o On-site manual operation
- o Intentional intervention from the ATC Center

b) The following information is shown on the wallmap display as necessary by sticking on magnetic sheets with symbolic depictions:

- o Incidents that limit the use of lanes
- o Temporary traffic restrictions
- o Others

2) Character CRT Displays

Traffic data received by the host computer can be retrieved via character CRT displays attached to operational work stations.

6.6.2 Work Station

Work stations are small computer sets linked to the host computer. They are being used increasingly as multipurpose traffic control consoles. The following ATC System operations are implemented by inputting the necessary instructions from the work stations located in front of the wallmap display.

1) Intentional Intervention

a) Green Band Control

Arrangement of a top priority offset by inputting the route and direction in which a given vehicle passes through.

b) Manual Plan Selection

Application of a given control plan or set of parameters to a subarea or intersection for realizing strategic outflow of traffic from a congested section.

c) Status Selection

Selection of stage sequence pattern or flashing.

2) Incident Input/Cancellation

Input or cancellation of any incident that limits the use of lanes.

3) Off-line Jobs

a) Operational Records

Output of hourly, daily, weekly or monthly records of the following items:

- Detector data
- Control plans selected
- Equipment failures
- On-site manual controls effected

b) Traffic Statistics

Processing of detector data and recording of the results onto magnetic tapes for the purpose of preparing traffic statistics.

c) Control Plan Renewal

Input of new control plans necessitated by changes in traffic conditions resulting from road construction or improvement.

4) Other Communication Equipment

Communication equipment other than man-machine interfaces that desirably would be located in the control room include the following:

- Radio broadcasting booth
- Radiophones (BMA, Traffic Police, Fire Service)
- Telephones
- Facsimile machine

6.7 Central Processing Unit and Peripherals

6.7.1 Hardware Configuration

1) Hierarchy Architecture

Under conditions of near-saturation or over-saturation, split control is effected in accordance with the plan information method, which is highly complicated. Moreover, the split control plan in this case should be renewed once every signal cycle or so.

In order to handle this complicated task at a fast speed, as well as to minimize throughput time from detectors to local controllers via the CPU and to obtain the necessary control capacity, a computer system with a hierarchy architecture was chosen. Under this system, the work load is shared by the host computer and front-end processors.

2) Dual System Configuration

A dual system was chosen for the host computer for backup and off-line job purposes.

3) Control Capacity and Future Expansion

Considering the fact that the number of intersections subject to the ATC System is 235, the control capacity of the CPU is established as corresponding to roughly 300 intersections. Future expansion will be effected by increasing the number of front-end processors. When expanding to more than 300 intersections, the use of subcenters may be effective, considering the need to lease lines. However, this matter will not be reviewed here.

4) Equipment Composition

a) Host Computer

The host computer is a 32-bit super minicomputer.

b) Front-End Processors

Front-end processors are equipped with 32-bit, 12 MHz microprocessors or higher. Each front-end processor has the capacity to handle 64 transmitting lines.

Fig. 6.7.1 shows the hardware configuration of the host computer, front-end processors and periperals. Fig. 6.7.2 shows the layout of the ATC Center, composed of the CPU and its peripherals and man-machine interfaces.

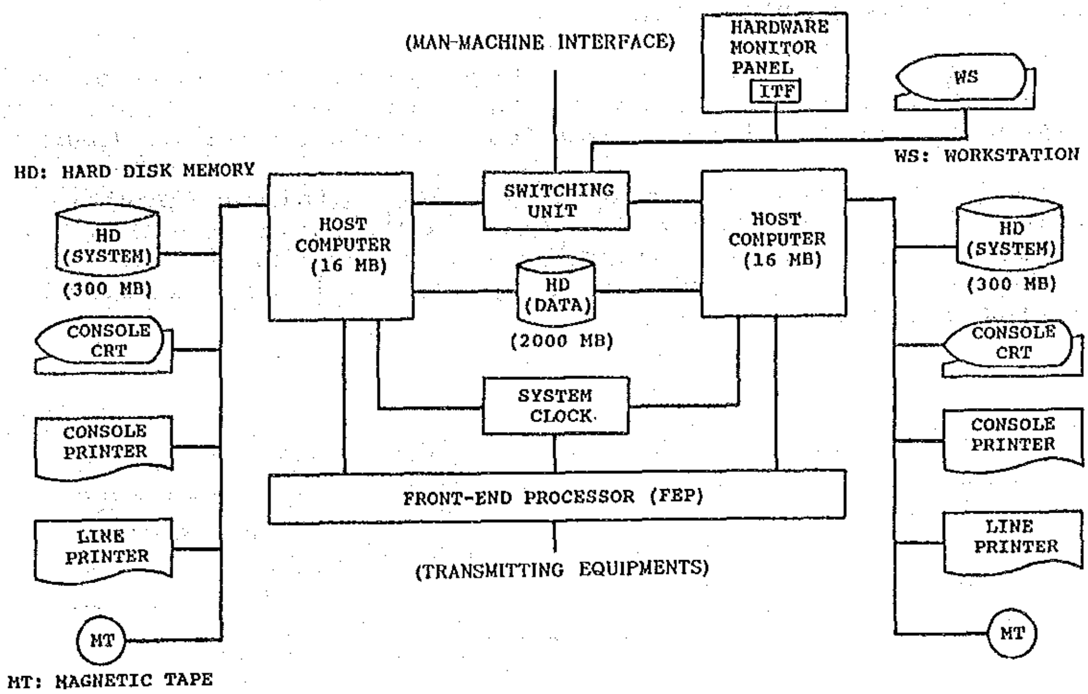


Fig. 6.7.1 Hardware Configuration

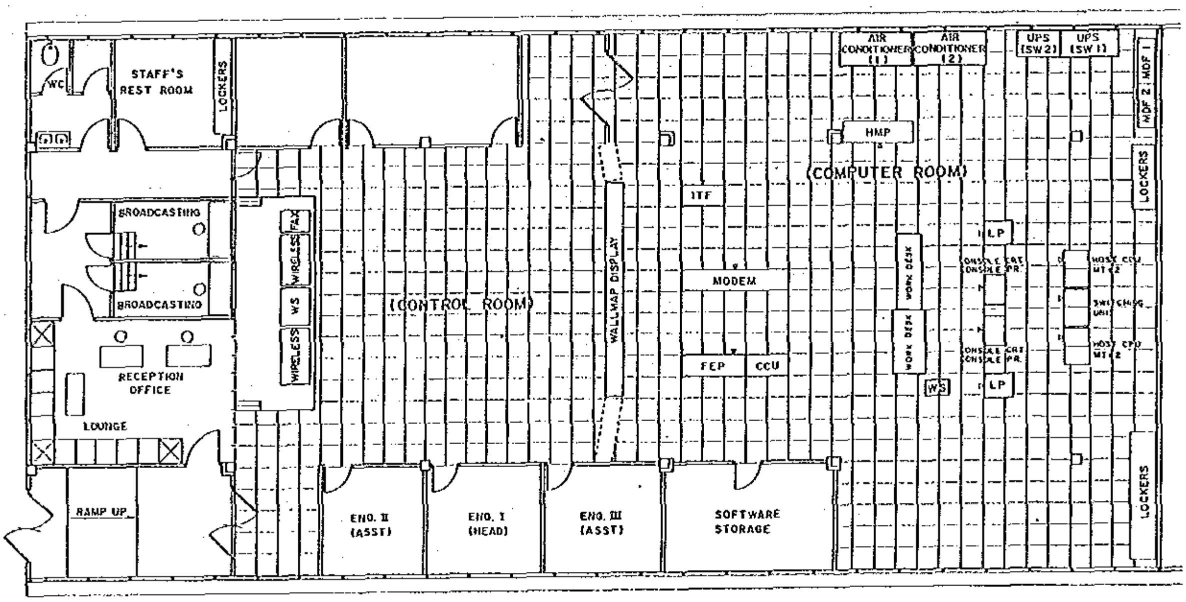


Fig. 6.7.2 Lay-Out of Central Equipments

6.7.2 Software Configuration

Fig. 6.7.3 shows the software configuration. The flow of real-time data-processing is shown in bold lines. These lines represent the most critical flow from the standpoint of load.

The cost estimate includes the depreciation portion of development cost, customization cost, and control plan formulation cost for each functional module shown in Fig. 6.7.3, plus the cost of generating a system that will organically interlink all these elements.

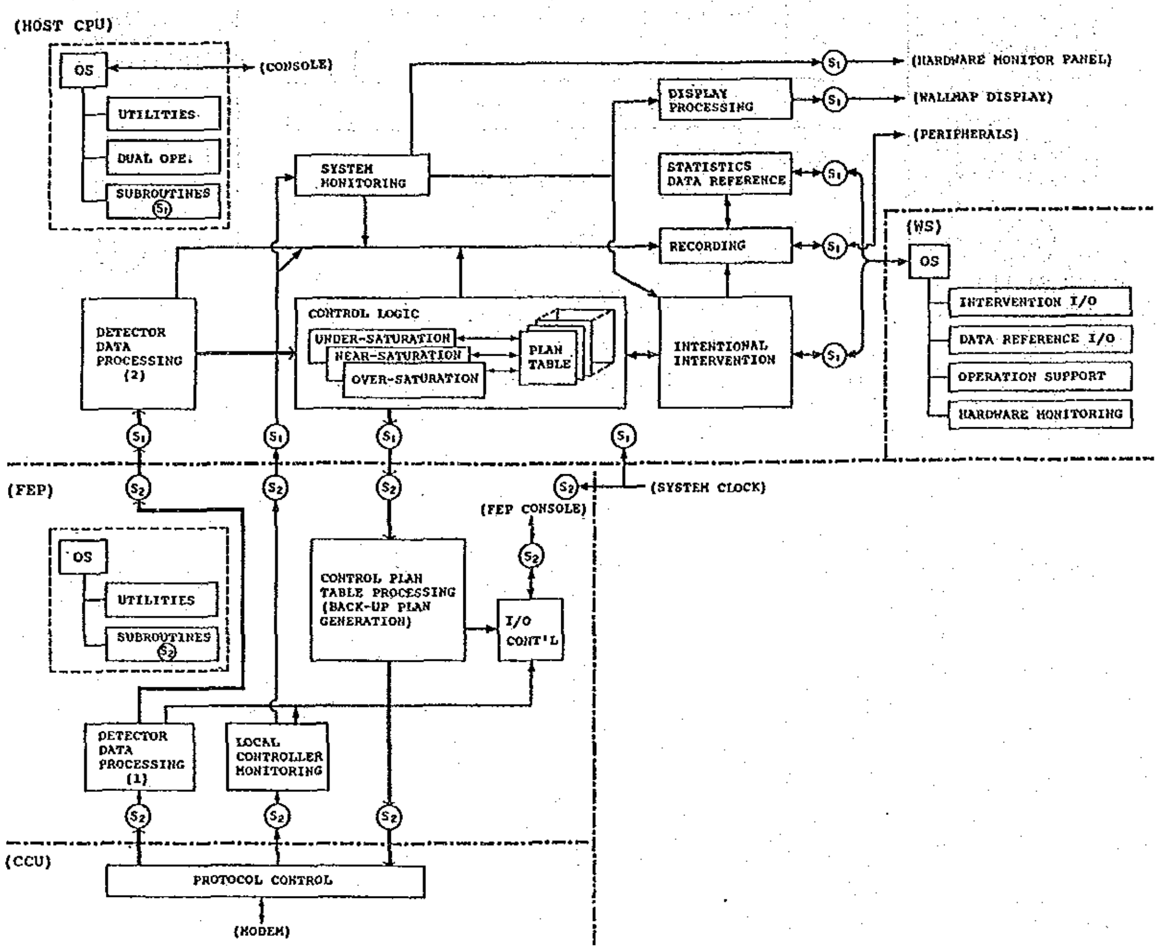


Fig. 6.7.3 Software Configuration

6.8 Proposed ATC System for Bangkok

Combining all the matters discussed in the preceding sections results in the ATC System proposed for Bangkok are shown in Fig. 6.8.1.

At present there is no direct relationship between both the ATC system functions and the Variable Traffic Sign system. The Variable Traffic Sign is very effective in alleviating traffic congestion. A plan for this system should be developed simultaneously with the ATC system in order to maximize the benefit of the system.

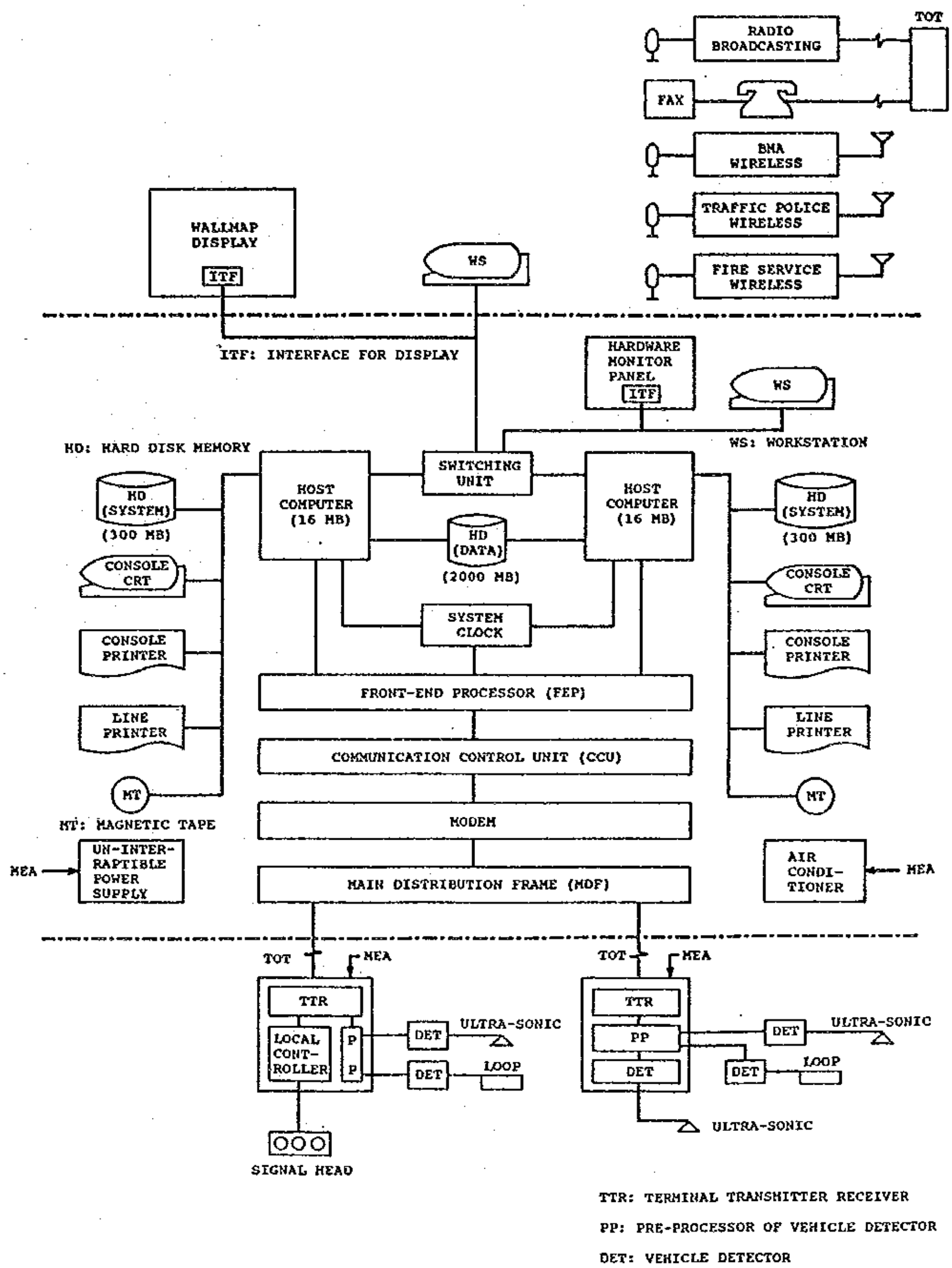


Fig. 6.8.1 ATC System for Bangkok

7

PROJECT COST ESTIMATE AND IMPLEMENTATION PLAN

CHAPTER 7 PROJECT COST ESTIMATE AND IMPLEMENTATION PLAN

7.1 Implementation Plan

For the implementation of the ATC System in the subject area, construction will be carried out in two stages with the aim of commencing System operation in 1993. The staging plan is shown in Table 7.1.1.

Table 7.1.1 Staging Plan

1990	1991	1992
	Stage I	Stage II
Target Area	143 intersections	92 intersections
Terminal Equipment	-143 local controllers -Vehicle detectors related to above	-92 local controllers -Vehicle detectors related to above
Central Equipment	-Host computer and its peripherals -Control plans for 143 intersections -Software for 143 intersections -Wallmap display and hardware monitor panel for 143 intersections -Air conditioner, UPS -All man-machine interfaces -FEP's, CCU's and modems in quantities required to handle terminal equipment installed	-Control plans for intersections added -Software for 92 intersections -Interface lines for wallmap display and hardware monitor panel in quantities required to handle additional terminal equipment installed -FEP's, CCU's and modems in quantities required to handle additional terminal equipment installed

The target area for Stage I, as shown in Fig. 7.1.1, is the area bordered by the Chao Phraya River, Ratchawithi and Din Daeng Roads, the Middle Ring Road, and Rama IV and Sathon Roads. Stage I covers 143 signalized intersections. The target area for Stage II consists of the ATC System Area other than the Stage I target area. Stage II covers 92 signalized intersections.

Target areas for Stages I and II were determined by evaluating the effects of the ATC System on vehicle delay time in various parts of the subject area.

The entire ATC System Area was divided into seven zones centering on the area within the Middle Ring Road, with the number of subject intersections in each of the zones as nearly the same as possible. At the same time, care was given so that traffic flow characteristics and road network within a zone would be as uniform as possible. Fig. 7.1.1 shows the resulting division of the subject area.

The effect of the ATC System (WITH, WITHOUT) on total delay time in each of the seven zones was then calculated for the morning peak hour, using the following evaluation index obtained through simulations.

$$Ii = \Delta Di/Si$$

Where,
- I : Evaluation index
- i : Zone
- ΔDi : Total delay time WITHOUT ATC minus total delay time WITH ATC in zone i
- Si : Total travel distance ATC (vehicle-kilometers) in zone i

In Zones 1, 2 and 3, which constitute Bangkok's CBD district, total delay time is reduced by about 60-70 seconds per vehicle-kilometer travelled when the ATC System is used. In Zones 4, 5, 6 and 7, the reduction is considerably less than 20 seconds per vehicle-kilometer travelled. It would therefore be more advantageous to give Zones 1, 2 and 3 priority when introducing the ATC System. Accordingly, these zones were established as the target area for Stage I.

Table 7.1.2 Evaluation Index

Zone	Index (seconds per vehicle-km)
1	68
2	73
3	61
4	20
5	21
6	20
7	12

The staging plan formulated in accordance with the target areas thus established is shown in Table 7.1.1. Stage I covers the period from mid-1990 to the end of 1992. Stage II covers the entire year of 1992.

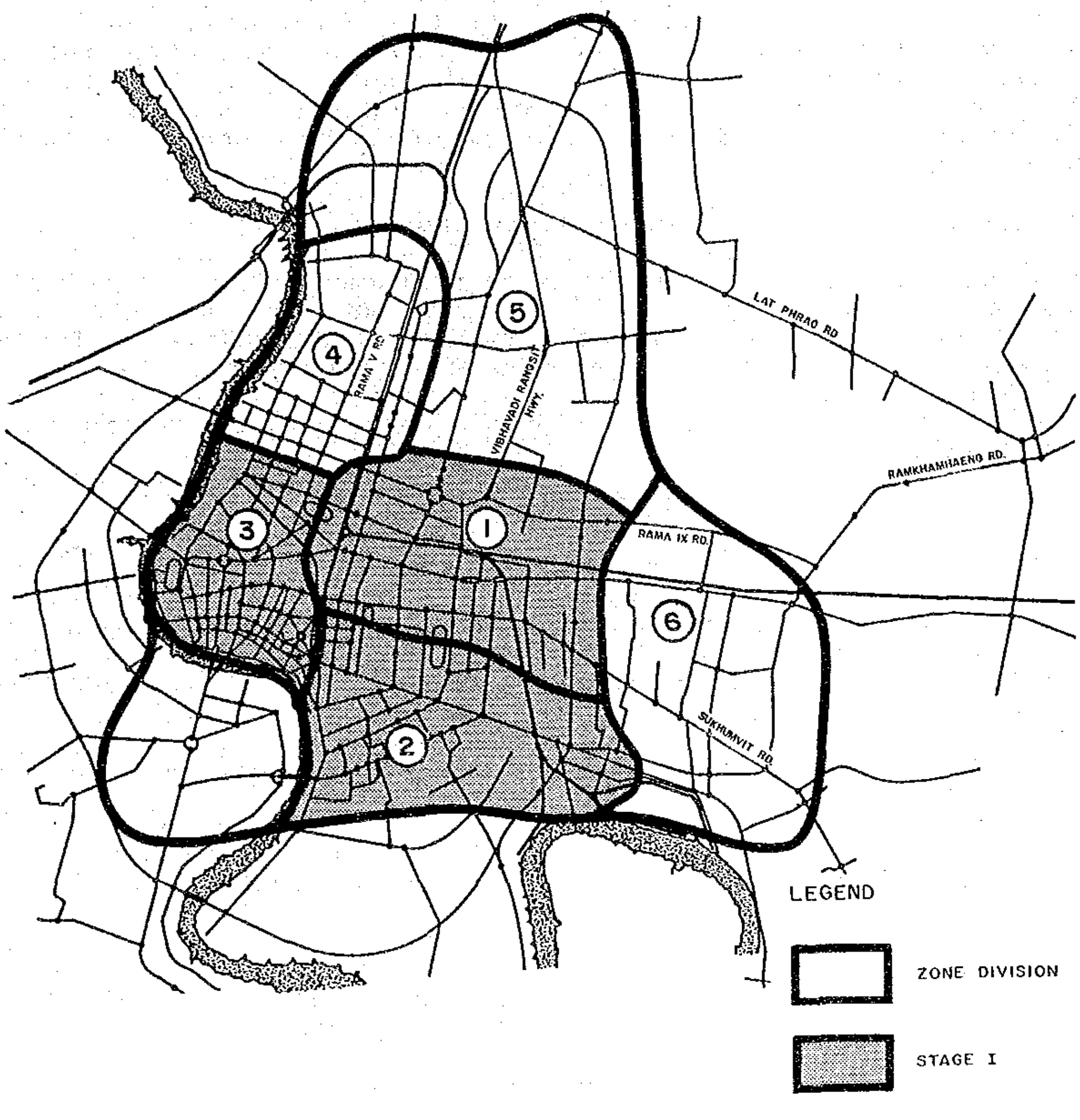


Fig. 7.1.1 Zone Division for Stage Plan

During Stage I, local controllers and vehicle detectors for 143 subject intersections will be installed with regard to terminal equipment. Concerning central equipment, the host computer and its peripherals will be installed, control plans for the 143 intersections will be prepared, and the software for 143 intersections will be developed. In addition, wallmap display, hardware monitor panel, air conditioners, UPS, man-machine interfaces, front-end processors, communication control units and modems will be installed.

During Stage II, local controllers and vehicle detectors for the remaining 92 intersections will be installed with regard to terminal equipment. Concerning central equipment, control plans for the 92 intersections will be prepared, and the software for 92 intersections will be developed. Interface lines for the wallmap display and hardware monitor panels required by the additional number of terminal equipment will be installed, together with front-end processors, communication control units and modems.

7.2 Project Cost Estimate

7.2.1 Standards for Calculating Construction Cost

To estimate the project cost of the ATC System, construction cost was calculated in accordance with the guidelines given below. Table 7.2.1 shows the unit costs of major existing construction items.

1) Unit costs of existing construction items are based on March 1989 data.

2) Unit costs of new construction items were calculated by adding labor, materials and equipment costs to March 1989 data.

3) Custom duty, business tax and municiptal tax imposed on imported equipment were calculated by applying the following percentages to the equipment's CIF prices.

Magnetic disc and tape devices	:	34.0873%
Other central equipment	:	56.4352%
Local controllers, detectors, and other signal equipment in general	:	32.9231%

4) The exchange rate was assumed to be 25 bahts per U.S. dollar.

5) Overhead, which is included in the indirect construction cost, was calculated by assuming Stage I to be 18 months and Stage II to be 12 months.

6) Profit, which is also included in the indirect construction cost, is given as 12% of the aggregate value of the direct construction cost and overhead.

7) Engineering service (detailed design + construction supervision) is given as 5% of the construction cost (direct + indirect).

8) A contingency of 5% of the construction cost was added.

9) The project cost of the Traffic Circulation Plan, which includes the reversible lane system, was calculated separately.

Table 7.2.1 Current Construction Unit Cost

Item	Unit	Cost(Baht)
1. Hand Hole	1 unit	1,200
2. Conduit Work		
Under side walk		
100 mm x 1 duct	1 meter	450
100 mm x 2 ducts	1 meter	860
Under carriage way (night work)		
100 mm x 1 duct	1 meter	885
100 mm x 2 ducts	1 meter	1,720
3. Cabling Work through Conduit		
2 core cable	1 meter	32
4 core cable	1 meter	50
8 core cable	1 meter	100
12 core cable	1 meter	125
4. High Pole with Boom Installation Work	1 set	13,000
5. Traffic Signal Head Installation Work		
1)Horizontal 3 aspects	1 head	15,000
2)Horizontal 3 aspects with 1 arrow	1 head	20,000
3)Horizonral 3 aspects with 2 arrow	1 head	25,000
4)Horizontal 2 Head of aspects	1 head	30,000
5)Vertical 3 aspects	1 head	13,500
6)Vertical 3 aspects with 1 arrow	1 head	19,000
7)Vertical 2 Head of 3 aspects	1 head	28,000
8)Pedestrian Signal	1 head	9,000
9)Pedestrian Rush Button	1 unit	3,500
6. Low Pole Work	1 set	1,600

Note ; Unit cost includes material cost,cost of labour and depriciation of machine & tool.

7.2.2 Standards for Calculating Operating Cost

The operating cost of the ATC System was estimated in accordance with the following guidelines:

1) The operating cost is based on July 1989 data.

2) Line rental charges include those for both existing and new lines.

3) Electricity charges include the additional charges (ATC Center and detectors) that will be incurred as a result of installing the ATC System.

4) Personnel and maintenance contractor expenses include the additional expenses that will be incurred as a result of installing the ATC System.

7.2.3 Project Cost Estimate

The project cost estimate for Bangkok's ATC System is given in Table 7.2.2.

7.3 Operational and Maintenance Setups

In order to realize the full purpose of the above-mentioned ATC System, all its equipment must be kept in good condition. To achieve this, it is necessary to organize the System's operational and maintenance setups in an efficient manner.

The operational setup should be such that it will be possible to provide the best traffic conditions to current road users and to raise the level of or expand the System in the future, as well as to facilitate the study of future road plans. At the same time, it is necessary to secure an operational staff that is sufficiently experienced and trained.

The maintenance setup should be such that it will be possible to implement periodic maintenance in an efficient manner so as to increase the System's reliability, as well as to effect speedy recovery work in the event of an equipment failure, in order to keep the effects of the failure to a minimum.

7.3.1 Operational Management

Main tasks involved in operational management are as follows:

1) Operational Management of ATC Center

   a) Communication with the central processing unit, and traffic operation related to instructions on emergency traffic control and manual selection of programs

   b) Information exchange related to agencies

   c) Traffic guidance of various sorts

   d) System operation

   e) Record-keeping of information-gathering documents and preparation of management books

2) Operational management related to ATC System Renewal and Expansion

Table 7.2.2 Cost Estimation on Bangkok ATC System Project

(Unit:Baht 1,000)

Stage	No. Description	1 Central Equipments	2 ditto Installation	3 Inter-section Equipments	4 ditto Installation	5 Detector Equipments	6 ditto Installation	7 Adjustment work on site	8 Staff Training	9 Project Management cost	Sub Total	10 Profit	11 Tax	12 Contingency	13 Engineering Service	Total	Import Duty
I	Financial cost (Foreign)	261,815	0	112,086	0	29,893	0	10,688	2,522	52,548	469,352	0	0	21,206	30,010	520,568	(-)
	Financial cost (Local)	63,043	3,420	40,193	17,478	11,896	11,406	0	242	4,910	152,588	68,375	28,717	12,138	3,334	265,152	(104,200)
	Tax	63,043	0	38,284	0	9,752	0	0	34	973	112,086	0	28,717	6,696	3,334	150,833	(104,200)
	Financial cost	324,858	3,420	152,279	17,478	41,789	11,406	10,688	2,764	57,458	621,940	68,375	28,717	33,344	33,344	785,720	(104,200)
	Economic cost	261,615	3,420	113,995	17,478	32,037	11,406	10,688	2,730	56,485	509,854	68,375	0	26,648	30,010	634,887	(-)
II	Financial cost (Foreign)	32,534	0	74,113	0	15,934	0	10,248	0	14,257	147,086	0	0	9,618	14,185	170,887	(-)
	Financial cost (Local)	13,959	669	26,494	12,737	6,306	6,288	0	0	3,648	70,101	32,320	13,575	6,146	1,576	123,718	(51,098)
	Tax	13,959	0	25,064	0	5,196	0	0	0	591	44,810	0	13,575	3,263	1,578	63,224	(51,098)
	Financial cost	46,493	669	100,607	12,737	22,240	6,288	10,248	0	17,905	217,187	32,320	13,575	15,762	15,761	294,805	(51,098)
	Economic cost	32,534	669	75,543	12,737	17,044	6,288	10,248	0	17,314	172,377	32,320	0	12,499	14,185	231,381	(-)
Total	Financial cost (Foreign)	294,149	0	186,199	0	45,827	0	20,936	2,522	66,805	616,438	0	0	30,822	44,195	691,455	(-)
	Financial cost (Local)	77,002	4,089	66,687	30,215	18,202	17,694	0	242	8,558	222,689	100,695	42,292	18,284	4,910	388,870	(155,298)
	Tax	77,002	0	63,348	0	14,948	0	0	34	1,564	156,896	0	42,292	9,959	4,910	214,057	(155,298)
	Financial cost	371,151	4,089	252,886	30,215	64,029	17,694	20,938	2,764	75,363	839,127	100,695	42,292	49,106	49,105	1,080,325	(155,298)
	Economic cost	294,149	4,089	189,538	30,215	49,081	17,694	20,936	2,730	73,799	682,231	100,695	0	39,147	44,195	866,268	(-)

Stage	Description	Inter-section Improvement	Operating cost
I	Financial cost (Foreign)	9,821	12,957
	Financial cost (Local)	5,015	12,088
	Tax	2,173	2,840
	Financial cost	14,836	25,045
	Economic cost	12,663	22,205
II	Financial cost (Foreign)	553	13,226
	Financial cost (Local)	281	12,015
	Tax	40	2,844
	Financial cost	834	25,241
	Economic cost	794	22,397
Total	Financial cost (Foreign)	10,374	-
	Financial cost (Local)	5,298	-
	Tax	2,213	-
	Financial cost	15,670	-
	Economic cost	13,457	-

a) Periodic inspection of traffic conditions

b) Checking and correction of signal phases, signal control paramaters, etc.

c) Review of signal facility additions and relocations

7.3.2 Maintenance Management

Maintenance management requires a set number of technicians who have the expertise to deal with each System device. However, financial and technical considerations make this difficult to achieve. Therefore, a contractor with thorough knowledge of the System and its equipment in general will be entrusted with and be responsible for the maintenance work.

The BMA will thus concentrate on System operation and will maintain the kind of setup that allows the beneficial effects of the System to be fully realized.

Main tasks involved in maintenance management are as follows:

-Equipment inspection
-Repair of failures

7.3.3 Staff Requirements

Staff requirements for effecting the maintenance and operational tasks described above are as follows:

1) Senior Traffic Engineer (1 person)

a) Overall management of the ATC Center, including both operation and maintenance.

b) Supervision of maintenance contractor

c) Instructions to operators concerning various guidance measures dealing with traffic problems

2) System Engineer (1 person)

a) Analysis of detector data and history reports

b) Fine-tuning and updating of control plans

c) Planning for System expansion and improvement

d) Instructions to software maintenance contractor

3) Electronic Engineer (2 persons)

a) Instructions to contractor entrusted with periodic equipment inspection and on-call based repairs

b) Contacting and coordinating with the TOT's maintenance department concerning transmission equipment maintenance

c) Assistance in planning for System expansion and improvement

4) Operators (5 persons)

6:00 - 21:00	2 persons x 2 shifts
21:00 - 6:00	1 person

All five to be transferred from current ATC System staff

a) Monitoring of traffic conditions through man-machine interfaces

b) ATC System intervention via control room work stations, based on instructions from the senior traffic engineer

c) Communication with related agencies such as Traffic Police

8

EVALUATION OF ATC SYSTEM

CHAPTER 8 EVALUATION OF ATC SYSTEM

8.1 Evaluation Method

Applying the cost-benefit analysis method, the ATC System stated in the previous Chapters is evaluated. That is, economic benefits expected to accrue by the ATC System implementation are compared to the project costs through discounted cash flow analysis.

Costs consist of the initial investment cost and operating cost of the project. Cost for such auxiliary works as gantry construction for traffic signals and channelization improvement are not included in this ATC System cost, because they will be needed regardless of the introduction of the ATC System in the long run.

Benefits are defined as savings in the total vehicle operating cost (VOC) and travel time cost (TTC) which are brought about by the ATC System introduction. These benefits are estimated based on the results of computer simulation of traffic flow for both cases of "with-" and "without- ATC System" control. In the latter case, traffic flow is simulated under the current management system.

The evaluation is not made from the standpoint of travellers nor any transport business agencies, but form the viewpoint of regional economy. Therefore, both costs and benefits are measured in terms of economic price, excluding transfer cost such as various taxes and subsidies.

The life-time of the ATC System is assumed to be fifteen years and benefits are estimated for the fifteen years after commencement of ATC control. Residual values of all the machines and equipments after fifteen years are ignored, as they would be very small because of the rapid technological evolution.

Evaluation will be made for two cases: one is evaluation of the ATC System as a whole where investment is made for both stage I and II, following the schedule recommended in the previous chapter and the other is evaluation of the stage 1 alone.

8.2 Economic Cost Estimation

The project cost explained in Chapter 7 are estimates at financial price (market price). Economic costs are obtained by deducting all kinds of taxes from those financial costs. Shadow prices of exchange rate and wage rate would not be necessary to apply, considering the current economic situation in Thailand. Although opportunity costs of facilities owned by the Government (such as ATC center building, parking lots, etc.) which are not included in the financial cost should be added to the economic cost, they are also ignored as they are negligibly small comparing to the initial investment.

Taxes excluded from the financial cost are import custom tax, business tax, local tax and income tax implied in personnel cost. The following tax rates are adopted;

(1) Import taxes refer to the Customs Tariff of Thailand (ver. September, 1988) issued by Customs Department.

(2) Local tax and business tax are 4.5% of the project cost.

(3) Average income tax rate is assumed to be 7.0%.

Total economic cost of the ATC System is estimated to be 866.3 million bahts, which corresponds to 80% of the financial cost 1(Table 8.2.1). Investment schedule in terms of economic cost is shown in Table 8.2.2.

Table 8.2.1 Economic Project Cost

(1,000 baht)

Stage	Financial Cost	Economic Cost
Stage I	785,720	634,887
Stage II	294,605	231,381
Total	1,080,325	866,268

Table 8.2.2 Investment Schedule at Economic Price

(1,000 baht)

		1990	1991	1992
Stage I	Engineering Cost	18,006	12,004	
	Construction Cost		604,887	
	(of which			
	ATC Center Cost)		(265,035)	
Stage II	Engineering Cost		5,674	8,511
	Construction Cost			217,196
	(of which			
	ATC Center Cost)			(33,203)
Total		18,006	622,565	225,707

As shown in Table 8.2.2, total cost includes the cost of central computer and supporting equipments at ATC center, which is 298.1 million bahts, about one third of the total. Especially, such cost in stage I occupies 42% of the total cost. However, the computer system and equipments installed in stage I are to be used also to the expanded area in stage II. For evaluation purpose, therefore, it is reasonable that ATC center cost should be re-allocated to each stage according to the size of its service area, e.g. number of intersections (143 in stage I and 92 in stage II). By this annual investment amounts are modified as shown in Table 8.2.3.

Table 8.2.3 Modified Investment Schedule at Economic Price

(1,000 baht)

		1990	1991	1992
Stage I	Engineering Cost	18,006	12,004	
	Construction Cost		521,322	
	(of which ATC Center Cost)		(181,480)	
Stage II	Engineering Cost		5,674	8,511
	Construction Cost			300,751
	(of which ATC Center Cost)			(116,758)
Total		18,006	539,000	309,262

Annual economic operating cost of the ATC System are estimated to be 22.2 million bahts for stage 1 and 22.4 million bahts in total after completion of stage 2, major part of which is personnel cost for maintenance of the System (Table 8.2.4).

Table 8.2.4 Operating Cost of ATC System

(1,000 baht p.a.)

	Financial Cost	Economic Cost
Stage I	25,045	22,205
Stage II	25,241	22,397

Note: Operting cost includes maintenance cost.

8.3 Benefits of ATC System

In order to estimate the benefits by applying the ATC System, traffic flow is simulated using a main frame computer. The simulation was made for 1993, the first year of the stage 1 and 2 ATC control.

For both cases of "with-" and "without ATC control", total delay time and total number of stopping are obtained as the simulation results, based on which savings in VOC and TTC are quantified. The OD traffic volumes are forecast, using the vehicle OD table surveyed in 1985 and future demographic framework developed in the study of the medium and long-term road and road transportation plan (SIMR/JICA).

1) Traffic Flow Simulation

Future traffic flow is simulated under the condition of two-way reversible lane system (case 5 in Chapter 5). "With-" and "without ATC control" are defined as follows;

(a) Traffic Responsive Control

Currently, cycle length and splits are manually varied by judgment of policemen at site, investigating traffic conditions. In this respect, manual control is a kind of traffic responsive control better than fixed-time control although its efficiency is lower than the responsive control by the ATC System.

As the manually controlled traffic signals can hardly be simulated in computer, the same algorithm of traffic responsive control as used for the ATC System is applied also in "without ATC control" case. By doing this, the benefit of the ATC System would be underestimated to some extent.

(b) Saturation Flow Rate

An observation of video record revealed that the saturation flow rates are rather low under present manual control. The saturation flow rates are, therefore, set in a lower level in "without ATC control" case, while the optimum cycle length to assure the highest flow rate is applied in "with ATC control" case, when traffic is nearly and over saturated.

(c) Signal Coordination

In "with ATC control" case, signals are coordinated, while in "without" case, each signal is independently controlled without coordination.

Simulation is conducted for one hour each of morning peak time, daytime and evening peak time. Total delay time and number of stopping are shown in Table 8.3.1. The ATC System can expectedly decrease the total delay time by 28% at morning peak time, 27% at daytime and 27% at evening peak time.

Table 8.3.1 Reduction of Total Delay Time and Stopping by ATC System

	Without ATC			With ATC		
	Morning 7-8:00	Daytime 13-14:00	Evening 17-18:00	Morning 7-8:00	Daytime 13-14:00	Evening 17-18:00
Total Delay Time (hours)	17,201 (1.00)	10,086 (1.00)	13,808 (1.00)	12,321 (0.72)	7,818 (0.78)	10,102 (0.73)
Total Number of Stopping (1000 times)	1,230 (1.00)	665 (1.00)	1,040 (1.00)	836 (0.68)	531 (0.80)	752 (0.72)

Note: Figures in ( ) shows the rate to "without ATC" case

2) Unit VOC and TTC

The aforementioned SIMR/JICA study has estimated and forecast VOC and TTC per 1,000 vehicle-kilometer in Bangkok for 1989, 1996 and 2006 (See chapter 6 of Interim Report II, SIMR Road Plan). VOC in 1989 is shown in Table 8.3.2 and TTC in Table 8.3.3, respectively.

Table 8.3.2 Vehicle Operating Cost by Speed in 1989

(Baht/000 Km)

Speed (Km/h)	Motor-cycle	Passen-ger Car	Light Bus	Medium Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Taxi	Samlor
5	995	5,504	4,744	8,936	15,968	4,967	7,529	9,567	5,396	2,475
10	899	4,838	3,404	6,159	11,957	3,591	5,656	7,259	3,817	1,586
15	795	4,266	2,796	5,028	10,055	2,987	4,867	6,223	3,189	1,271
20	726	3,866	2,471	4,429	9,044	2,671	4,428	5,634	2,876	1,104
25	675	3,562	2,258	3,995	8,416	2,467	4,167	5,289	2,680	998
30	635	3,326	2,117	3,733	7,963	2,328	3,970	5,012	2,548	927
35	607	3,143	2,015	3,544	7,628	2,235	3,851	4,850	2,455	878
40	583	2,988	1,945	3,394	7,351	2,168	3,759	4,718	2,376	843
45	565	2,861	1,893	3,284	7,118	2,115	3,715	4,653	2,320	816
50	552	2,766	1,848	3,221	6,914	2,083	3,668	4,588	2,285	796
55	539	2,686	1,826	3,188	6,833	2,054	3,639	4,549	2,260	785
60	531	2,686	1,807	3,159	6,767	2,033	3,621	4,529	2,239	782
65	536	2,689	1,812	3,169	6,712	2,017	3,622	4,540	2,224	786
70	533	2,692	1,820	3,192	6,738	2,007	3,631	4,561	2,210	794
75	534	2,704	1,835	3,222	6,752	2,007	3,663	4,619	2,205	805
80	539	2,720	1,868	3,289	6,806	2,013	3,734	4,740	2,206	821

Table 8.3.3 Travel Time Cost by Speed in 1989

(Baht/000 Km)

Speed (Km/h)	Motor-cycle	Passen-ger Car	Light Bus	Medium Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Taxi	Samlor
5	5,480	14,700	10,360	22,800	55,340	0	0	0	8,180	8,180
10	2,740	7,350	5,180	11,400	27,670	0	0	0	4,090	4,090
15	1,827	4,900	3,453	7,600	18,447	0	0	0	2,727	2,727
20	1,370	3,675	2,590	5,700	13,835	0	0	0	2,045	2,045
25	1,096	2,940	2,072	4,560	11,068	0	0	0	1,636	1,639
30	913	2,450	1,727	3,800	9,223	0	0	0	1,363	1,363
35	783	2,100	1,480	3,257	7,906	0	0	0	1,169	1,169
40	685	1,838	1,295	2,850	6,918	0	0	0	1,023	1,023
45	609	1,633	1,151	2,533	6,149	0	0	0	909	909
50	548	1,470	1,036	2,280	5,534	0	0	0	818	818
55	498	1,336	942	2,073	5,031	0	0	0	744	744
60	457	1,225	863	1,900	4,612	0	0	0	682	682
65	422	1,131	797	1,754	4,257	0	0	0	629	629
70	391	1,050	740	1,629	3,953	0	0	0	584	584
75	365	980	691	1,520	3,689	0	0	0	545	545
80	343	919	648	1,425	3,459	0	0	0	511	511

3) Economic Benefit of ATC System

Road network used for simulation consists of 781 links in total (447 links for stage I area and 334 links for stage II area). The sum of products of traffic volume and unit VOC plus TTC of each link will give the total hourly traffic cost in the simulated area. The difference of these traffic costs in "with" and "without ATC" case is regarded as the benefit of the ATC System.

Prior to the calculation above, unit VOC and TTC have been aggregated, taking into account the vehicle type composition in the simulation area. Dividing the area into seven zones as shown in Fig. 7.1.1, average vehicle type compositions are as in Table 8.3.4 according to the survey in January, 1989.

Table 8.3.4 Vehicle Type Composition in Simulation Area

(Unit: %)

Type/Zone	1	2	3	4	5	6	7
Passenger Car	35.8	35.8	35.8	35.8	35.8	33.7	23.1
Pickup,Light Truck	15.9	15.9	15.9	15.9	15.9	20.6	18.2
Truck	3.0	3.0	3.0	3.0	3.0	6.2	5.0
Taxi,Samlor	16.4	16.4	16.4	16.4	16.4	10.3	13.4
Mini Bus	0.9	0.9	0.9	0.9	0.9	2.0	2.6
Bus	3.6	3.6	3.6	3.6	3.6	5.0	4.7
Motorcycle	24.1	24.1	24.1	24.1	24.1	20.0	32.7
Others	0.4	0.4	0.4	0.4	0.4	2.2	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source:JICA Study Team

At first, the benefits during the simulated three hours are estimated and then they are expanded to dayly benefit using average hourly traffic variation of the area (Fig. 8.3.2). Here, benefits are computed only for 7:00 A.M. to 7:00 P.M. and benefits during other time period are ignored.

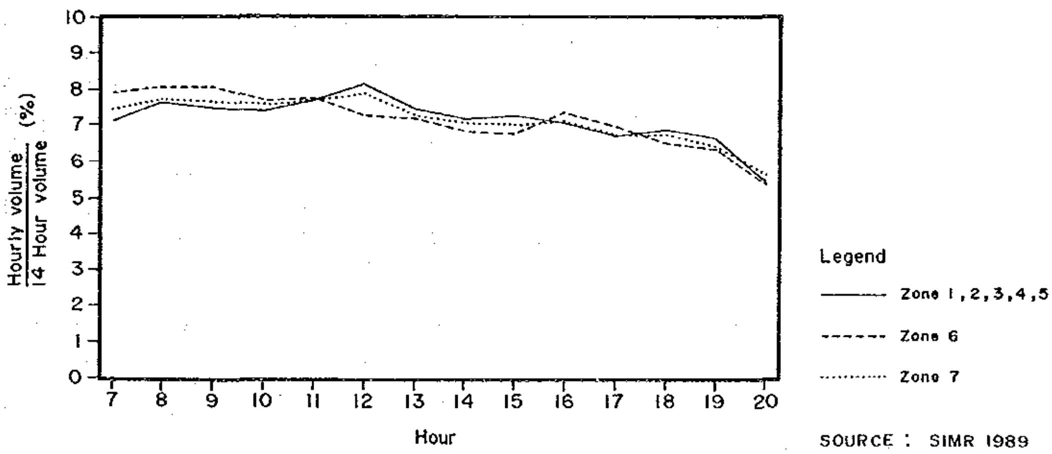


Fig. 8.3.1 Hourly Fluctuation of Traffic Volume in Simulated Area

Traffic volume and vehicle type composition of the area are assumed not to change for the coming fifteen years. This is mainly because almost all the links are already saturated, especially in the peak time and it is difficult to conduct the computer simulation to larger volume of traffic than present one. If traffic volume increases actually in the future, this assumption will make underestimated of the benefit of the ATC System.

Table 8.3.5 shows the estimated benefits in 1993 to 2007. By implementing stage 1 and stage 2, the first year benefit will be 1101 million bahts which exceed the total economic cost of 866 million bahts. About one fourth of this benefit accrues from VOC saving and the other three fourth from TTC saving. As people's time value rises in the future, this benefit will increase up to 1,763 million bahts in 2007, 1.6 times of the first year benefit.

Stage 1 generates about 70% of the total benefit and stage 2, 30%. Considering that the stage 1 area comprises 57 intersections while the stage 2 area, 43 intersections, stage 1 has comparatively higher economic efficiency than stage 2.

Table 8.3.5 Economic Benefits in 1993 to 2007

Million Baht

Stage I				Stage II				Stage I+II			
Year	VOC Saving	TTC Saving	Total	Year	VOC Saving	TTC Saving	Total	Year	VOC Saving	TTC Saving	Total
1993	181	540	722	1993	89	290	379	1993	271	830	1,101
1994	185	570	755	1994	91	306	397	1994	276	876	1,152
1995	189	599	788	1995	94	322	415	1995	282	921	1,203
1996	192	629	821	1996	96	337	433	1996	288	966	1,254
1997	195	654	848	1997	97	351	448	1997	292	1,004	1,296
1998	198	678	876	1998	99	364	462	1998	296	1,042	1,338
1999	200	703	903	1999	100	377	477	1999	301	1,080	1,380
2000	203	727	931	2000	102	390	492	2000	305	1,118	1,423
2001	206	752	958	2001	103	403	507	2001	309	1,155	1,465
2002	209	777	985	2002	105	417	522	2002	314	1,193	1,507
2003	212	805	1,017	2003	107	432	538	2003	318	1,237	1,555
2004	215	835	1,049	2004	108	448	556	2004	323	1,283	1,605
2005	218	866	1,082	2005	110	464	574	2005	328	1,330	1,656
2006	221	898	1,116	2006	112	482	592	2006	333	1,380	1,709
2007	224	931	1,151	2007	114	499	612	2007	338	1,431	1,763

8.4 Evaluation and Conclusion

In comparison of benefits and cost of the ATC System, evaluation indicators such as internal rate of return (IRR), net present value (NPV) and benefit / cost ratio have been calculated as shown in Table 8.4.1 for the whole project (stage 1 and stage 2) and Table 8.4.2 for stage 1 only. Discount rate is 12% which is commonly used in Thailand as capital opportunity rate.

IRR of this project is as extremely high as 75% and all the initial investment will be covered within 12.1 months after commencement under 12% of discount rate. NPV amounts to 5,631 million bahts and B/C ratio is estimated at 8.3.

Evaluating the stage I alone, IRR is 74%. Although it is slightly lower than that of whole project, utmost return is assured. B/C ratio is as high as 7.5.

Though nobody would deny that time has economic value, there are many arguments on how to measure it. In this study, time value is quantified based on the productivity of economically active population in the Study Area. Even in cases this unit time value is admitted, there may be objections to apply this value to a small fraction of a few minutes of saved travel time.

Then, taking only VOC saving benefit which is tangible one, IRR is re-calculated at 17.2 which shows the ATC project is still economically feasible.

There are not many with so high economic return in public investment projects of infrastructure. Thus, high priority should be given to this project and it is strongly recommended to start this project immediately with preparation of detail design and implementation plan and fund procurement.

Table 8.4.1 Evaluation of ATC Project (Stage I and Stage II)

(1,000 Baht)

Year	Cost	Benefit	B-C	B-C discounted by 12% p.a.
1990	18,006		-18,006	-16,007
1991	539,000		-539,000	-429,688
1992	309,262		-309,262	-220,127
1993	22,397	721,658	699,261	444,393
1994	22,397	1,151,967	1,129,570	640,949
1995	22,397	1,203,027	1,180,630	598,144
1996	22,397	1,254,088	1,231,691	557,154
1997	22,397	1,296,225	1,273,828	514,478
1998	22,397	1,338,363	1,315,966	474,550
1999	22,397	1,380,500	1,358,103	437,273
2000	22,397	1,422,639	1,400,242	402,536
2001	22,397	1,464,776	1,442,379	370,223
2002	22,397	1,506,914	1,484,517	340,213
2003	22,397	1,622,050	1,599,653	327,321
2004	22,397	1,745,983	1,723,586	314,893
2005	22,397	1,879,384	1,856,987	302,915
2006	22,397	2,022,979	2,000,582	291,373
2007	22,397	2,177,544	2,155,147	280,254
Total	1,202,223	22,188,096	20,985,873	5,630,778

Internal Rate of Return (%)	75.1
Net Present Value (million B.)	5,631
Benefit/Cost Ratio	8.27

Table 8.4.2 Evaluation of ATC Project (Stage I only)

(1,000 Baht)

Year	Cost	Benefit	B-C	B-C discounted by 12% p.a.
1990	18,006		-18,006	-16,077
1991	533,326		-533,326	-425,164
1992	22,205		-22,205	-15,805
1993	22,205	721,658	699,453	444,515
1994	22,205	754,812	732,607	415,701
1995	22,205	787,965	765,760	387,958
1996	22,205	821,118	798,913	361,388
1997	22,205	848,494	826,289	333,724
1998	22,205	875,869	853,664	307,840
1999	22,205	903,245	881,040	283,671
2000	22,205	930,620	908,415	261,148
2001	22,205	957,995	935,790	240,194
2002	22,205	985,370	963,165	220,732
2003	22,205	1,016,543	994,338	203,461
2004	22,205	1,048,704	1,026,499	187,537
2005	22,205	1,081,881	1,059,676	172,856
2006	22,205	1,116,108	1,093,903	159,321
2007	22,205	1,116,108	1,129,213	146,842
Total	906,612	14,001,801	13,095,189	3,669,843

Internal Rate for Return (%)	73.9
Net Present Value (million B.)	3,670
Benefit/Cost Ratio	7.50

APPENDIX

APPENDIX

OVERVIEW ON EXISTING AREA TRAFFIC CONTROL SYSTEMS IN THE WORLD

1.1 CURRENT STATUS OF ATC SYSTEMS IN MAJOR COUNTRIES

1) United Kingdom

(1) General

At the present time in U.K. there are 24 signal systems which are able to coordinate nearly 5,000 signal controllers altogether on fixed time plans. The largest such system in London, where computers in New Scotland Yard are connected over telephone lines to about 1,200 signal controllers.

Many of the fixed time signal systems use timing plans which are based on TRANSYT, an off-line optimisation tool which will be described in TRANSYT. Quite often the plans have been modified manually to make partial updates that accommodate changes in the local traffic situation. Whilst overall the fixed time signal systems have proved to be highly cost effective, experience has shown that it is difficult to devote resources to producing completely new signal plans as often as is desirable to maintain high efficiency. It is reported that the need for, but burden of updating fixed time plans is a key reason why in recent years in U.K. most orders for new signal systems have specified traffic responsive control by SCOOT. In some places, conventional fixed time signal systems are being replaced by SCOOT. SCOOT is a highly automatically traffic-dependent system and will be briefly described in SCOOT.

(2) SCOOT

SCOOT (Split, Cycle and Offset Optimisation Technique) is one of the most well-known on-line plan formation control methods in the world today. It has been developed in U.K. since 1973.

In SCOOT, although pretime plan selection is basically performed, SCOOT has two features of traffic-responsive control as follows:

a) Green splits and offsets are modified cycle by cycle around the values of the selection plan on real time and traffic-responsive basis.

b) The signal plans which are loaded in the computer are automatically updated according to the results of real time modification which is mentioned above.

The signal timing values in the plan in use are always readjusted by means of exponential smoothing of the existing and modified values. This automatic updating function assures that there are no needs not only for updating but also for preparing any initial plans. The system can start from any arbitrary traffic signal settings.

A detector is installed 5 to 15m from upstream end of each lane of the approaches of all the intersections to detect vehicle passage as well as queue spill-back in the link (Fig. A-1). Using 'platoon flow profile' similar to what is used in TRANSYT, the arrival flow at the downstream stop line is predicted and accordingly delay. number of stops, and queue length are estimated. To determine the optimum green split and cycle length, 'degree of saturation' is used. Green splits are modified to balance the degree of saturation at each approach by small increments. Subareas are fixed in the SCOOT system, and the common cycle length is updated every 2.5 minutes between the upper and lower limits so that the maximum value of degree of saturation at each approach in the most heavily loaded intersection would be 90%. Together with the changing of cycle time, offset decisions are made in such a way that weighted sum of delay and number of stops at each link are minimized.

The relative effectiveness of SCOOT varies by area and time of day but it is reported that SCOOT achieves an average saving of delay about 12% in the five areas in U.K. where it was compared with good fixed time plans.

There are some aspects to be considered in application of SCOOT as follows:

a) It is rather expensive to install and maintain a large numbers of detectors.

b) SCOOT can be applied to undersaturated conditions, and is not suitable for highly saturated conditions.

c) SCOOT may not be cost-effective for those cities where labour costs are not very high because the greatest merit of SCOOT is in automatic updating of timing plans.

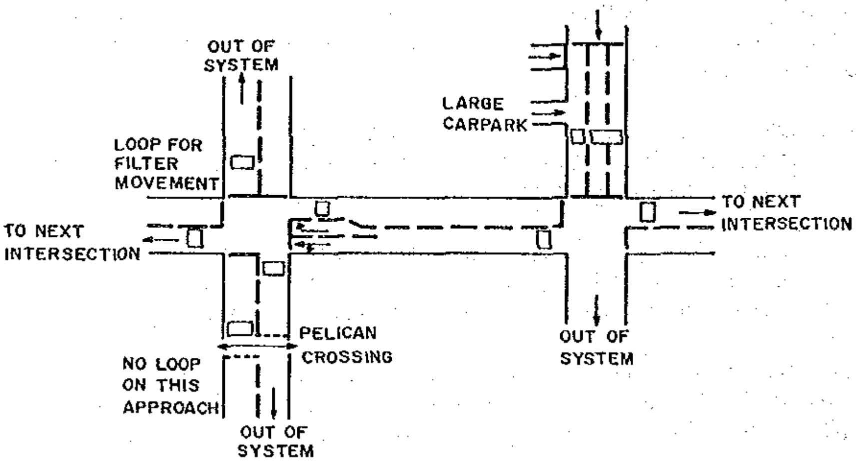


Fig. A-1 Typical Layout of Loop Detectors for SCOOT

2) France

(1) General

More than 50 French cities, representing almost all of the cities of more than 80,000 inhabitants are now equipped with centralized traffic signal systems.

A typical example of control strategies in France is as follows. The intersections in the control area are divided into a number of sectors based on the analysis of the coherence of the traffic in a given sector as compared to the others. A sector may comprise from 10 to 50 intersections. The strategies at the area level are based on the automatic selection of precomputed traffic plans. The selection process works in two steps.

Firstly, the selection at the sector level is made in the following ways, unless any predictable variations of traffic flow occur in some sector, for example the end of work of a big factory or a big sporting event. Automatic analysis of the traffic every 3 minutes with either of two different processes are made depending on the level of congestion in the selected links:

a) if the level of congestion in these links is under a given threshold, the most suitable pattern of parameters is selected. The measurements use a linear combination of occupancy and volume and they are smoothed over a 12 minutes periods.

b) if the level of congestion in the selected links of the sector exceeds the threshold, then the selection process uses only a subset of the measurement points in order to give a marked priority to the relief of the congestion in the selected links.

After the isolated selection of a traffic plan by each sector, eventually some adjustments between sectors are made by traffic engineers in order to modify this choice to take into consideration a special problem in a sector or group of sectors. For example, if a given sector has chosen a traffic plan for congestion and if the surrounding sectors are non-congested, it may be wise to modify the choice of the surrounding sectors in order to restrict the incoming flow and to allow a fast exit from the congested sector.

The switching process from a given traffic plan to another takes generally one to two cycles, exceptionally three.

Next to the plan selection for each sector, some automatic local modification may be made by the central computer on a cycle by cycle basis for individual intersections. The use of standard vehicle actuated control is usually limited to some periods of the nighttime with very little traffic flows. Anticongestion actions are performed to protect the pre-selected low capacity links from oversaturation by storing the excess of vehicles in the neighbouring links with higher storage capacity. Special congestion detectors are installed at the end of the low capacity links and the green times of the high capacity links feeding the low capacity ones are modified at each cycle according to the level of congestion on these detectors.

3) Australia

(1) General

There are about 5,500 traffic signals in Australia, most of which are installed in capital cities each with a population of 1 million or more. Control methods of the ATC systems in Australia can be classified into four types as follows:

a) fixed-time control which is still used in some parts of the Melbourne CBD,

b) traffic-adaptive selection of preset signal plans according to the informations from strategically located detectors which is used in some arterial roads in Brisbane,

c) linked vehicle-actuated (VA) control in which VA intersection controllers are used in a fixed-time area control system, e.g. in parts of the Melbourne, Adelaide and Brisbane CBD's, and

d) traffic responsive control using the Sydney Coordinated Adaptive Traffic System (SCAT), which will be explained further in SCAT.

(2) SCAT

SCAT (Sydney Coordinated Adaptive Traffic system) is another resent research product of on-line plan formation control and developed by the Department of Main Roads, New South Wales (DMR-NSW) in the last decade in Australia. Over 3,000 signalised intersections in the world are now in operation under the control of SCAT as seen in Table A-1.

Table A-1 Implementation of SCAT (as of September 1987)

City	Number of signals connected to SCAT	Number of regional computers
Sydney & other NSW cities	1,350	17
Melbourne	984	14
Adelaide	300	6
Perth	124	2
Canberra	60	1
Hobart	60	2
Darwin	12	1
New Zealand cities	270	8
Shanghai	30	1
Tianjin	20	1
Singapore	24	1
Total	3,234	54

At all intersections under SCAT control loop detectors are required on all of the approach lanes at the location of 1.5m upstream from the stop lines except on the exclusive left turn lanes. In a SCAT system, the whole area is divided into smaller sub-areas of about one to 10 signalised intersections that share a common cycle time. The common cycle time is updated every cycle in steps of up to 6 sec according to the degree of saturation of that sub-area. Green times are so controlled cycle by cycle that the degrees of saturation of the phases of an intersection come closer. Various VA control tactics are also available. Each sub-area has five offset plans which are predetermined as part of the input data-base and one out of the five is selected in a traffic-responsive manner.

It is reported that SCAT was found to be particularly successful in reducing stops compared with a fine-tuned fixed time control which was optimized using TRANSYT.

The detectors installed close to the stop line as shown in Fig. A-2 contribute to observe the degree of saturation precisely in response to the variation of traffic flow. This detector layout, however, makes it impossible to measure the flow profile, therefore the offset plans cannot be formed in SCAT but should be produced by an off-line tool such as 'CLOFFSET'.

It should be noted that SCAT is applicable to undersaturated traffic conditions. The detector locations of SCAT which is immediately upstream of stop lines are suitable for measuring the degree of saturation only in the range of low degree of saturation.

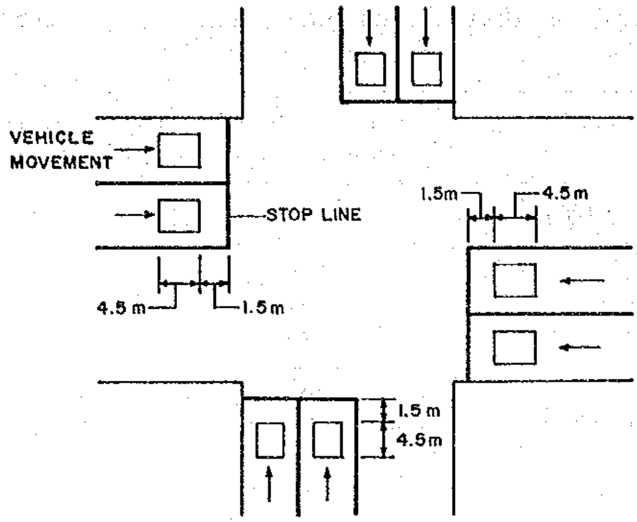


Fig. A-2 Typical Layout of Loop Detectors for SCAT

4) USA

(1) General

From 1968 to 1975 in USA, the Urban Traffic Control System (UTCS) project was established by the Office of Research of the Federal Highway Administration (FHWA). The objectives of this project was to develop and test new computer-based control strategies under real world conditions. The control strategy research associated with the UTCS project has been divided into three generations:

a) First generation control - prestored timing plans developed by off-line optimization techniques

b) Second generation control - computes timing plans on-line based on current traffic data

c) Third generation control - computes timing plans on a cycle-by-cycle basis

The Institute of Transportation Engineers prepared a report in January 1987 based on a survey of traffic signal systems in the Unite States and Canada. A total of 245 traffic signal systems were identified with 143 in operation, 58 under construction, and 44 in planning stage. A selected list of systems is shown in Table A-2 which includes only those systems in the United States that have over 100 signalised intersections and 150 detectors.

About one-half of these systems use a UTCS-based software and the others use different softwares which have been developed by leading manufactures and system consultants, many of which utilize knowledge gained from the earlier UTCS experiments.

Most of the systems in operation today use conventional plan selection control (first generation control). The timing plans are established by using off-line optimization tools like TRANSYT. A few on-line control strategies based on current traffic data (the one and half - to the second generation control) are being applied experimentally in some of the systems.

Table A-2 Selected Traffic Signal System in U.S.

State	City	Type of software	No. of signals	No. of detectors
AL	Birmingham	Computran	278	185
AR	Little Rock	Honeywell	146	400
CA	Los Angeles	UTCS Enhanced	118	396
CT	Hartford	UTCS Enhanced	128	255
FL	Dade County	UTCS FORTRAN	1,500	1,400
ID	Ada County	Honeywell	149	300
IN	Evansville	Computran	207	350
KY	Lexington	Computran	240	228
LA	New Orleans	UTCS FORTRAN	206	264
MN	Minneapolis	CSE	705	450
NC	Durham	Sperry SRT	164	180
NC	Winston-Salem	UTCS 2nd Generation	211	548
NE	Lincoln	UTCS FORTRAN	205	400
NV	Las Vegas	UTCS Extended	345	1,080
NY	Nassau County	Sperry SRT	313	190
NY	Nassau County	Other CSI-FORTRAN IV	120	190
NY	New Yourk City	Other NYC VTCS	3,000	2,700
NY	Rochester	UTCS FORTRAN	312	405
TN	Knoxville	Other MTCS	165	277
TX	Dallas	UTCS FORTRAN	206	353
VA	Arlington City	Sperry SRT	194	233

5) Japan

(1) General

Table A-3 shows the numbers of traffic signal controllerd intersections of various types in Japan as of March 1987. The total number of traffic signals is approximately 122,000 out of which 34,500 are in the area control systems in 74 cities. The control principle of area control is basically conventional traffic-adaptive plan selection type. Green times of the critical intersections, however, are usually controlled in the manner of traffic-responsive plan-formation method.

A whole area of a system is divided into a number of subareas in such a way that the traffic condition varies in a similar manner within a subarea. The signal timings that are cycle length, green splits and offsets are determined for each of the subareas individually in principle.

Ultrasonic vehicle detectors are usually used mainly because of maintenance reasons. The vehicle detectors are installed at 150 to 200 meters upstream of the stop lines of all the approaches of major intersections.

Since traffic-adaptive plan selection control is a widely used control method in the world today, the way in which the plans are selected in the Tokyo System is described in detail in (2) as a typical example of this type of control.

Table A-3 Traffic Signals in Japan (as of March 1987)

Type	Number of Traffic Signalized Control Intersection
Area Control (74 cities)	34,510
Coordinated (3,8860 groups)	19,499
traffic-responsive	5,247
pretimed multi-program	12,584
pretimed single-program	460
coordinated push button	1,208
Isolated	67,795
full traffic-actuated	1,039
semi traffic-actuated	6,439
bus/rail-responsive	390
pretimed multi-program	39,223
pretimed single-program	588
push button	19,471
others	645
Total	121,804

(2) TOKYO SYSTEM

"M Value", the measure of traffic conditions

A weighted sum of volume (V) and occupancy (O),

$$M_{ijk} = a * V_{ijk} + b * O_{ijk}$$

is used as the measure of traffic condition of the ith approach of the jth phase at the kth intersection. The weighting factors a and b are so determined that a*V is roughly equal to b*o when traffic is nearsaturated. The value of M is considered to be a good measure of degree of saturation of the approach in under - to nearsaturation conditions.

Cycle length

Cycle length of a subarea is determined in such a way as follows:

The M value of the jth phase of the kth major intersection is defined as

$$Mjk = \max_{i}(Mijk)$$

where i is the approach number.

The M value of the kth intersection is defined as

$$Mk = \sum_{j} Mjk$$

The cycle length for the kth major intersection Ck is determined depending on the Mk value in such a way that Ck is longer when the Mk value is larger as shown in Figs. A-3 and A-4. The cycle time of the subarea C is determined as the largest of Ck's for all k in the subarea.

When the difference in the cycle times that are selected in the above mentioned manner between the two adjacent subareas is smaller than a preset value, the longer cycle time is used as the common cycle time for both of the two subareas. This procedure of cycle time determination is carried out every 5 to 15 minutes.

Green split

Green splits of major intersections are determined based on the M values of the phases as shown in Fig. A-4. At critical intersections program formation type of control is used in nearsaturation conditions. The average detector pulse length is measured every cycle on all the approaches at 150 to 200 meters upstream from the stop lines. This value which is called "P value" has been found to be a good indicator of the degree of saturation of the stop line and is used to control green split so that all the phases are saturated to nearly the same extent. Green times of all the phases are reallocated every cycle depending on the P values of last cycle in such a way that the green time of a phase is increased/decreased when the P value of the phase is above/below the average of all the phases.

This method has advantages over the conventional vehicle-actuated control in two aspects. Firstly there is no difficulty in maintaining the given cycle time. Secondly there is no need to shut down the pedestrian flows earlier than the vehicular flows. In the conventional vehicle-actuated control pedestrian flows should be terminated before the vehicular extension period. This tends to cause too long cycle times and pedestrian complaints as well. In the method mentioned above, however, there is no need

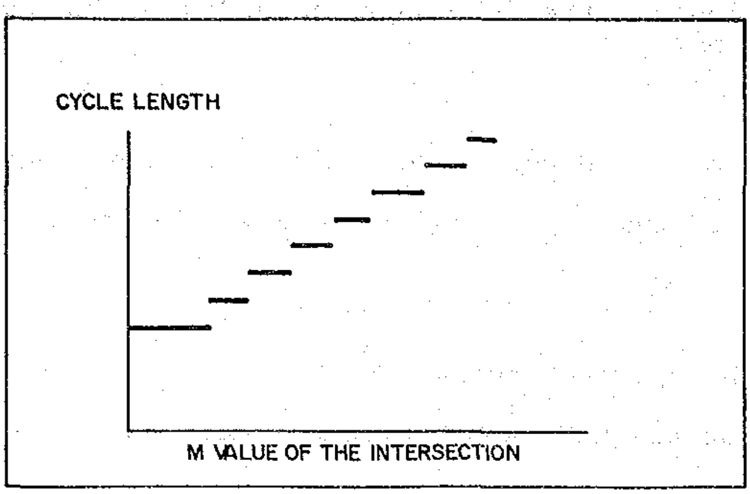


Fig. A-3 Cycle Length Selection

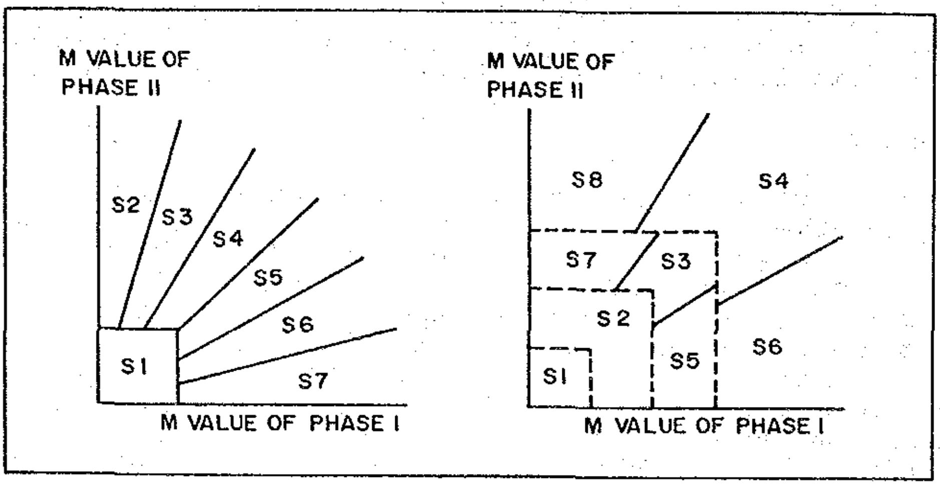


Fig. A-4 Green Split Program Selection

of early cut of pedestrian flows because the green times are decided before the cycle starts so that no sudden end of green is necessary.

In oversaturated conditions at critical intersections queue length-responsive control of split is used. Vehicle detectors are installed at locations of 300, 500 and 1,000 meters upstream of the stop line to measure the queue length and the green times are so controlled that the length of the queues of the conflicting phases become closer to each other.

Offsets

Offset program selection is carried out every 5 minutes but there is a limit of minimum time of use of an offset program so that any one of the offset programs should stay in use at least for 15 minutes once it becomes in use. In case a new program is selected before expiration of the minimum time of the current program the new program is simply neglected and the old program keeps staying in use. This is for the purpose of avoiding too frequent disturbances caused by offset transition from one program to another which takes up to four cycles.

When a queue spills back from the downstream intersection to the exit area of the upstream intersection, the green time for this direction at the upstream intersection cannot be fully utilized because of the reduced saturation flow rate. In the current version of the software there is no particular attention paid to this situation.

The revised version, however, will take this condition into account in such a way that the green time is shortened when a queue spilling back to the exit area is detected by the detector located in the exit.

1.2. OFF-LINE OPTIMISATION TOOLS

For plan selection type of signal control, off-line preparation of signal timing plans is essential. Though traffic engineers can determine them manually, since it requires much skill and time to produce signal plans manually, computer-based methods of calculating these plans are now widely used.

1) TRANSYT

Several optimisation programs for an areawide control have been developed in the world. Most commonly used software is the TRANSYT (TRAffic Network StudY Tool) method in U.K. (Robertson et al, 1968).

TRANSYT uses a static network simulation model in which traffic flow in a study network is expressed by the 'cyclic flow profile' assuming that the traffic arrival and departure are identical in every cycle. The geometry of the networks and traffic volumes should be given in advance as the input data. TRANSYT optimizes mainly offsets so that a weighted sum of delay and number of stops in the area is minimized in a similar manner to a trial and error method. Several values of cycle times and green splits are tested if so commanded and the optimal ones are searched. The latest version can be run on standard microcomputers.

It is reported that use of TRANSYT method for fixed time coordination is likely to yield savings in delay by 20 to 40% depending on the network configuration in the undersaturated conditions compared with isolated vehicle-actuated operation.

In near - to oversaturated conditions, however, since the most important objective of signal timings should be maximizing the capacity of the whole area, cycle times and green splits at the critical intersections should be the major concern instead of the network offsets. TRANSYT is therefore not suitable for highly saturated conditions.

2) OTHERS

There are several other optimization tools.

In French cities, in addition to TRANSYT a French program THEBES which is similar to TRANSYT is used to optimise coordination. UTCS which is widely used in the US is said to utilize the method similar to TRANSYT. In F.R.Germany, a new optimization procedure for network traffic signal control is being developed. This procedure which has been named SIGMA (SIGnal MAnagement) is to make use of experiences gained with various models known internationally, e.g. SIGOP, combination method, TRANSYT and MITROP.

3) PROBLEMS

(a) In order for traffic engineers to use these tools, an enormous amount of input data such as phase arrangements, green splits for the phases, volumes of all directions, and link length are required. Cost and labour for preparing those input data, especially for carrying out field traffic survey are often more than what the traffic engineers can afford. This is the major reason why the signal plans are generally not updated as frequently as desired and get obsolete world wide.

(b) These off-line optimization tools are mainly or only concerned with undersaturated conditions. In heavy traffic conditions like in most of Japanese cities, the signal plans produced by these tools are not suitable.

1.3. SUMMARY OF CONTROL STRATEGIES OF THE REPRESENTATIVES SYSTEM

Table A-4 Summary of Control Strategies of The Representative Systems

System	Cycle PS	Cycle PF	Split PS	Split PF	Split VA	Offset PS	Offset PF	Location of Detectors
existing * Bangkok's	FT		FT			FT		no detectors
UTCS *	TR		TR			TR		
Japan	TR		TR	FB		TR		150 to 200 m upstream from stop line
SCAT *	FB		FB			TR		close to stop line
SCOOT *	FB		FB				FB	upstream end of the links

Legends PS : Plan Selection
PF : Plan Formation
VA : Vehicle Actuated
FT : Fixed Time
TR : Traffic Responsive
FB : Feed-Back
* : Adaptation of undersaturation traffic flow

Note : Vehicle Actuated Control

The simplest form of plan formation is vehicle-actuated (VA) control of green times which is not linking control but localized split control. Vehicle arrivals at an approach are detected by a vehicle detector and the green time to the approach is extended when the vehicles arrive continuously with the headways shorter than a certain preset value which is usually 2 to 3 seconds.

1.4 VARIOUS METHODS FOR COPING WITH TRAFFIC CONDITION VARIATION

Signal timings should be changed according to change of traffic condtions. Even for the same amount of traffic demand, longer green time should be given if the road capacity is reduced. There are several ways to change signal timings to cope with road and traffic conditions. These are grouped into the three major types of control methods as are shown in Table A-5.

Table A-5 Matrix of ATC Methods

	Pretimed Control	Traffic-responsive Control
Plan Selection	Pretimed Multi-plan Selection	Traffic-adaptive Multi-plan Selection
Plan Formation	Non Existing	Traffic-responsive Plan Formation

Note:(1) Plan selection means that one of several preset plans prepared off-line in accordance with patterns of traffic condition is selected according to the preset time or fixed interval.

(2) Plan formation means that signal control plan is prepared on the basis of cycle-to-cycle fluctuations in traffic demand as indicated by detectors.

(3) Pretimed plan selection control
The simplest method of signal timing control is pretimed plan selection control in which one out of several preset signal timing plans is selected to switched into operation according to the preset time schedule usually depending on time of day and day of week.

(4) Traffic-adaptive plan selection control
The second simplest form of signal timing control is traffic adaptive plan selection control in which one out of several preset plans is selected to be put into use depending upon the prevailing traffic condition as being measured by the vehicle detectors. The selection of plans is carried out usually once every 15 minutes, that means that traffic condition in last 15 minutes determines the signal plan for the coming 15 minutes.

JICA