has been employed by the Department of Town and Country Planning. It is suggested, therefore, that DOH should divide the country into 4 blocks, namely, North block, North-East block, Center block, South block and conduct the OD survey by the block.

Since traffic demand is expected to grow rapidly due to the dramatic economic growth of the country, it is better to conduct the survey as often as possible to maintain the validity of data. However, in view of the fact that traffic volume survey has been conducted directly by the Traffic Engineering Division, it is practical that the OD survey be conducted every 5 years.

In summary the suggested OD survey to be conducted by DOH is as follows:

A. The country is to be divided into 4 blocks, ie. North block, North-East block, Center block, South block and the Survey is to be conducted within each block.

B. The survey is to be conducted annually in each block. For the nation-wide data, the accumulated data in each block are to be combined every 5 years to prepare nation-wide OD Table .

At the present time, the Traffic Engineering Division directly conducts the survey. However, it should be considered to entrust such survey with some external organization. If it is judged impossible to conduct the survey in a certain block in a single day, the block can be further divided into sub-blocks to obtain the data.

5.6.3 Continuous Traffic Volume Observation Survey

DOH conducts traffic volume surveys every year. Among these, a Control Count Survey is conducted at 35 points on the National Highway 4 times a year for 7 days (3 days for certain time range) to measure traffic on 24-hour basis and to identify changes in traffic volume by season or by time of a day. It is unfortunate, however, that this is not sufficient basic data required for traffic engineering analysis, and it is suspected that day-to-day traffic management suffers because of this lack of basic data.

A Continuous Traffic Volume Observation Survey employs vehicle detectors and can collect data on a 24-hour basis all year round. This method will not only collect basic data for traffic engineering analysis but also can provide useful data for improving reliability of the traffic census. Therefore it is recommended that the Continuous Traffic volume Observation Survey is adopted for this study.

The basic idea on how to select survey points for Continuous Traffic Volume Observation Survey is described in Chapter 5.5.2. In practical terms, it is reasonable to assume those points which DOH has selected to conduct control count survey are appropriate for this survey. Thus, in the future, it is proposed to conduct the Continuous Traffic Volume Observation Survey at all stations where, the control count survey is currently conducted.

The amount of data to be collected by the Continuous Traffic Volume Observation Survey should be about the same as the amount collected by the control count survey. It is desirable that the travel speed of passing vehicles are also measured at the same time. Taking that into consideration, the vehicle detectors to be used for this survey should be at about the same level as the ones installed along Route 31 by DOH. Table 5.9 describes the functions of vehicle detectors installed along Route 31.

Vehicle detectors with functions described in Table 5.9 are fairly expensive. It is expected that it will take some time before all 35 control count survey stations are equipped with such detectors. Referring to the analysis results in Chapter 3, priority of early installation of equipment should be given to those stations with higher congestion levels. In installing detectors, it is also important that vehicle detectors are installed equally throughout the country.

Table 5.9 Functions of Vehicle Detectors on Route 31

Items	Functions
Classification of vehicle types	- Passenger car - Small-Size truck - Large-size truck - Bus
Output data	- Number of monitoring lane; 6 lanes max - Recording method; paper tape punch - Recording time intervals; 5 min, 30 min, 1 hour - Recording data; traffic volume, average speed, occupancy

CHAPTER 6 TRAFFIC INFORMATION SYSTEM

CHAPTER 6 TRAFFIC INFORMATION SYSTEM

6.1 STUDY PURPOSE AND PROCEDURE

Owing to the yearly increasing volume of vehicular traffic in the nation's urban regions, traffic flow in city centers as well as surrounding areas is being widely affected by spontaneous congestion during rush hours and bottlenecks caused by accidents and construction work, with the result that the regions' socioeconomic activities are being disrupted. In order to ensure the smooth and safe flow of traffic under these conditions, it is necessary from the standpoint of road management, to keep in constant touch with actual traffic conditions and to provide the necessary information to the necessary locations promptly and accurately. The more the road network becomes dense and complicated, the more information on traffic conditions will be demanded by road users.

Taking the above factors into consideration, the study described in this chapter proposed the introduction of a traffic information system for DOH-managed roads by capitalizing on the Japanese experience in setting up a similar system. A flow chart of the study procedure is given in Figure 6.1.

The survey was carried out in the vicinity of Don Muang Airport on mid July 1989. As a part of the Study, a survey on traffic information required by motorists was carried out in a way outlined in Table 6.1.

Table 6.1 Outline of Survey on Motorist's Traffic Information Needs

Objectives	1) Identify traffic information desired by drivers 2) Identify motorists needs on an interest in congestion and travel time information
Time Frame	Mid-July 1989
Location	Don Muang Airport
Method	Interviews by survey staff
Contents	1) Trip and driver attributes 2) Traffic information desired 3) Favored method of obtaining traffic information 4) Response to congestion information

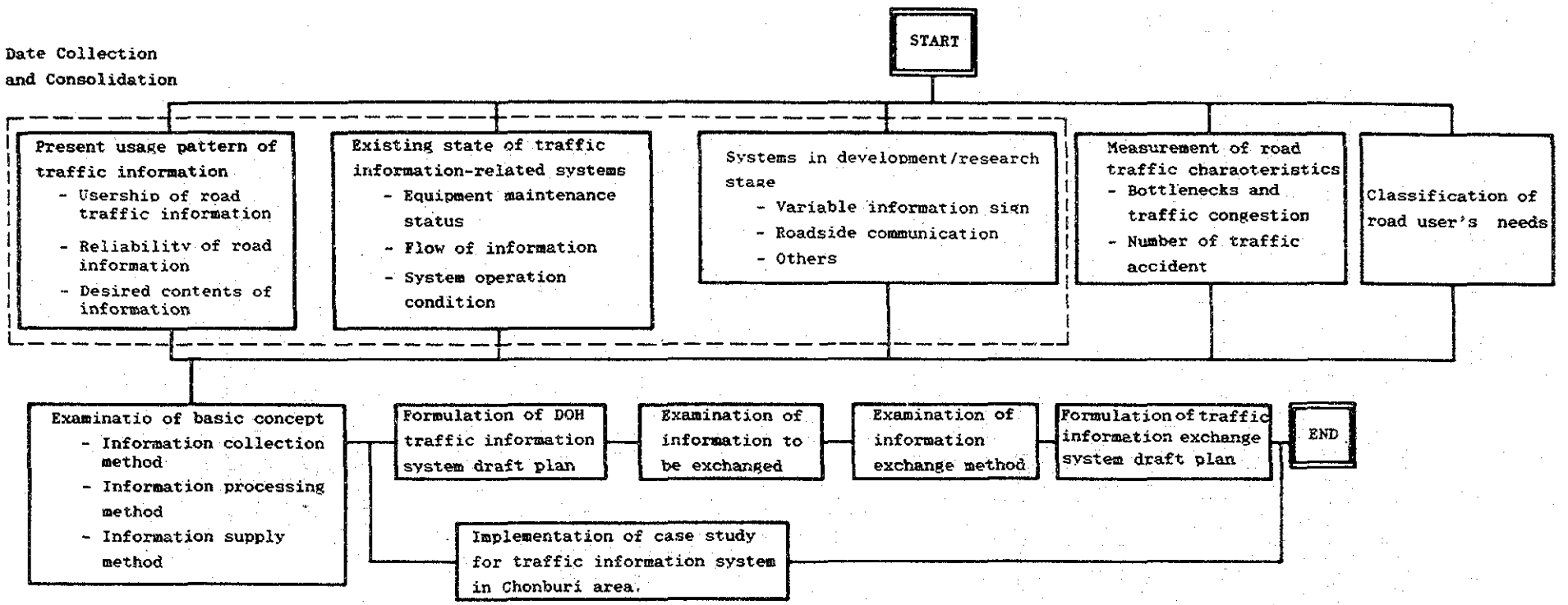


Figure 6.1 Study Flow Chart for Traffic Information System

6.2 CURRENT TRAFFIC INFORMATION

6.2.1 Types of Traffic Information

There are some items to classify traffic information can be classified into a number of categories. Traffic congestion, accidents, road construction work, weather, traffic restrictions are the most common information provided to drivers in Japan. Variable message signs by the roadside, radio broadcasting, radio, TV, and telephone are used as the media to communicate such information.

This information helps drivers to estimate travel time and to select the best route, and therefore, greatly contributes to smooth traffic operation.

However, in recent years in Japan, drivers wish to obtain the more diversified and up-to-the-minute information. To cope with such demand, a highly sophisticated system which is capable of providing such information as "fastest route", for example, is desired by drivers.

Table 6.2 shows the classification of traffic information practised in Japan; however some items are still in experimental stages. In the case of Thailand, information such as traffic restriction and accidents, and routing information are the most needed information from the view point of its social demands and drivers awareness.

6.2.2 Collection Method of Information

In Thailand, traffic information is conveyed to drivers via radio broadcasting (see Appendix 6.1) and ETA variable message signs (see Appendix 6.2). The variable message signs in ETA has been used on an experimental basis. The source data for those information are collected from Highway Police.

In Japan, these types of information as shown in Table 6.3 are collected mostly from vehicle detector, traffic monitor TV, emergency phone and patrol cars. These information are used for traffic control operation and conveyed to drivers by means of variable message signs (letter, picture), and by roadside broadcasting system.

Table 6.2 Types of Traffic Information

Type of Information	Detail
Road Guidance	1) Detailed information on network and road - Type of road - Route name - Route No. - Distance - Passing point - Lane No. - Width - Pavement condition - Land mark - Road structure (IC, Ramp) - Toll - Restriction - Rest area - Parking 2) Current location of traveling vehicle 3) Approach information between trunk road and destination/origination point - Auxiliary road network - Town name - Public facilities
Traffic Information	1) Restriction - Closed road - Limited entrance - Forced exit - Detour - Speed restriction 2) Congestion 3) Accident/Road works - Traffic accident - Works - Stopping vehicle - Fallen object 4) Disaster - Fire - Damaged road
Route Guidance	1) Travel time estimation for several routes 2) Shortest route 3) Detour information due to accident, road works, restrictions
Roadside Guidance	1) Service information for traveling vehicle - Rest area - Parking area - Gas station - Mechanic - Hospital - Parking 2) Sightseeing, Event, Weather Report, Other Transportation, etc.

Table 6.3 Collection Method of Traffic Information

Collection Method	Information Collected
Vehicle Detector	- Level of congestion - Travel time on freeway - Route guide
Meteorological Observation Apparatus	- Direction and speed of wind
Traffic Surveillance Cameras	- Traffic condition - Accident/stopped vehicle condition - Lane closed condition
Emergency Phone	- Accident - Stopping vehicle
Radio Communication from Patrol Car	- Accident/stopped vehicle condition - Weather
Information Exchange with Other Organization	- Traffic information of other roads
Others	

6.2.3 Traffic Information Media

Current features or those under consideration on traffic information media used in Japan are summarized in Table 6.4. In Japan, traffic information is conveyed to drivers using letter sign, picture signs, regular radio broadcasting and roadside broadcasting. Among the media listed in Table 6.4, variable message signs (including those used in ETA for experimental purposes, see appendix 6.2), regular radio broadcasting (now being in practice, see Appendix 6.1) and telephone services are the ones needed in Thailand at present.

6.2.4 Problems Concerning Traffic Information System

(1) Problems in Present System

Table 6.5 summarizes the problems concerning traffic information system in Thailand and recommendations in the future.

(2) Basic Ideas on Traffic Information System

From the users' view point, it is ideal if traffic information can be obtained 1) at anytime, anywhere (free from time & place), 2) and the information that one wants (ensured quality and personalization of information), 3) without delay (instantaneousness) and by 4) various media (selectivity).

Point 1) : free from time and location-drivers wish to obtain traffic information at home or office before departure, and also at the entrance to freeway and during traveling, including mobile communication.

Table 6.4 Type of Traffic Information Media

Information Media	Characteristics
Letter Sign Board	- Easy to understand while driving - Contents of information limited
Picture Sign Board	Traffic conditions for large area can be displayed
Radio Broadcasting	- Easiest and frequent access - Available in a car
Information Terminal	At service area and parking area, detailed and up-to-date information can be provided using video display and private videotex
Roadside Information Board	- Easy to understand while driving - Location limited to freeway entrance
Roadside Broadcasting	Drivers can obtain traffic conditions on particular road
Telephone	Information is provided by operator or by tape recorder
Videotex	Detailed and real time information is obtained upon request
Exclusive Radio Broadcasting	Detailed information can be frequently obtained
CATV	- ditto -
Personal Radio Communication	Effective communication area is limited within 3 - 5 km diameter
Character Broadcasting	Selective reception by program is possible
MCA	Effective communication area is 20 km diameter without interference and intercept
Facsimile	Detailed information can be provided

Table 6.5 Current Problems and Future Recommendation on Traffic Information System in Thailand

	Current Problems	Recommendations for Future
Collection of Data	Data is poorly provided by patrol cars and drivers.	Introduction of vehicle detectors and traffic surveillance cameras.
Information Processing	Information processing depends solely on police officer's judgment.	Establishment of Traffic Management System to cope with amount of data to be collected through vehicle detectors and traffic surveillance cameras.
Conveyance of Information	Regular radio broadcasting and variable message sign (currently used by ETA) are the only equipment used for this purpose.	Expansion of information provision facilities such as letter/picture sign board and telephone services.

In Tokyo, as an example, variable message signs are installed every 2 km (average) along a freeway. This

interval is acceptable for traffic congestion due to saturation because drivers can see the sign every 10 minutes. However, in the case of serious congestion caused by an accident, drivers may get frustrated because they can only see the sign every half an hour.

Point 2) : the quality of information-value added information system which provides the information on traveling time, traffic situation, weather, favorable sight seeing site and pattern data for travel planning, is ideal.

Personalization of information means providing only necessary information required by individual driver properly. At present, such a service is impossible with existing media. Only closest way is a telephone conversation made by driver to inquire any specific information to that authority. Most of the time, drivers have to select relevant information from a huge amount of information and act according to his judgment. It would greatly reduce the psychological burden on drivers if it becomes possible to provide personalized information such as optimum routing to destination.

Point 3) : in Tokyo, traffic data on metropolitan freeways are processed every minute to minimize time lag of information with actual conditions.

To respond to drivers' basic needs, establishment of traffic information system which satisfies point 1) to 3) is required. In the case of Thailand, it is recommended, in view of its social needs and socioeconomic conditions, to expand traffic information facilities to achieve better traffic operation in the following stages as described in Table 6.6.

Table 6.6 Management Level

Stage	T a r g e t
Stage 1	Collection of data from patrol cars and telephone calls by drivers.
Stage 2	Introduction of information gathering system, information provision system, and traffic control system. However, the judgements will also be done by operators.
Stage 3	Introduction of management support system. This system connects traffic phenomena, weather phenomena, and other factors to management processing. The processed data are stored in computer in which the result will be output when a similar case arises.
Stage 4	Introduction of traffic prediction system. This system predicts traffic phenomena which is used to perform dynamic traffic flow control with close examination of effectiveness of control method used for the case under scruting.

6.3 INITIAL CONSIDERATIONS FOR TRAFFIC INFORMATION SYSTEM

6.3.1 Data-Gathering Devices and Their Placement

Assuming that traffic information is to be provided actively in Thailand in the future, data-gathering devices required for present include:

- Vehicle detectors
- Traffic surveillance cameras

The criteria for selecting the locations of the above-mentioned devices should be considered in the following;

1) Congestion

Bottlenecks, occur at fixed points within a road network, and can be expected to occur most frequently, with respect to ordinary roads at signalized intersections.

2) Diverging traffic flow

For example, locations where detours or alternative routes are available.

3) Alteration of road network

For example, locations where changes in the road network due to the construction of a bypass or a new road occur.

4) Alteration of geometric element

For example, locations where changes in the road capacity due to the alterations in the geometric configuration of a road, such as an improvement of an intersection or road widening occur.

5) Change in demand

For example, locations where changes in the quantity and quality of traffic demands due to the development of a housing area, factory or some other facility occur.

6.3.2 Informational Devices and Their Placement

Assuming that traffic information is to be provided actively in Thailand in the future, informational provision equipment required for the time being, in addition to the ordinary radio equipment already available, include variable-message signs and a telephone service system.

Location of variable-message signs should be determined in accordance with the following guidelines:

A. Well in advance of points or areas where congestion occurs frequently, in order to give drivers sufficient time to respond to congestion information.

B. Near intersections where route changes are possible, in order to allow drivers to respond to detour information.

C. When a variable-message sign is to be placed near an intersection, it should be placed at a point upstream from the intersection, in order to give drivers sufficient time to change lanes or make other necessary movements.

Concerning the telephone service system, it is necessary for the organization responsible for road management to work together with the telecommunication company in promoting the system.

6.4 TRAFFIC INFORMATION EXCHANGE SYSTEM

6.4.1 Necessity of Traffic Information Exchange System

Roads can exhibit their intrinsic functions only when they are fully improved from and to end, as the old saying goes, "All roads lead to Rome." This holds true with all roads placed under the control of the DOH. The DOH roads, having a total length of 49,800 km, can be use by motor vehicle traffic throughout the country only if they are linked to all other highways and roads.

To the highway user, the differences between road administrators are a matter of little concern because the roads he chooses to complete his trip are perceived as a singles route. It is therefore important to provide drivers with the information they need where they need it, and this information service should be offered on a total, country-wide scale, little influenced by the division of road administration boundories. When provided with such information, drivers can take appropriate action to complete the rest of the trip. Traffic information covering all road administrators is thus essential for drivers using the DOH roads.

The roadnetwork in Thailand consists of the following roads. Table 6.7 Shows the road administrators of all these roads.

1) Roads stipulated in the Road Law

   a. Special highways
   b. National highways
   c. Provincial highways
   d. Rural roads
   e. Municipal roads
   f. Sanitary roads
   g. Concession highways

2) Roads placed under the control of the ETA Expressways

The purpose of the traffic information exchange system is to secure a smooth and efficient exchange of information between the DOH and other road administrators. It is also intended to facilitate the information exchange between the DOH and its internal sections including local offices and other related organizations excluding road administrators.

Table 6.7 Road Administrators

Road	Road Administrators
Special highways	Department of Highways
National highways	Department of Highways
Provincial highways	Department of Highways
Rural roads	The Office of Accelerated Rural Development, Department of Royal Irrigation
Municipal roads	Bangkok Metropolitan Administration
Sanitary roads	District Council
Concession highways	Department of Highways Bangkok Metropolitan Administration
Expressways	Expressway and Rapid Transit Authority of Thailand

6.4.2 Initial Consideration for Traffic Information Exchange System

There are a number of factors to be carefully examined in planning traffic information exchange, and these in clude the kind of information to be exchanged, the time and method of exchange, and the assingnment of personnel for information exchange.

This in turn makes it necessary to determine where and what information is to be collected by each individual road administrator, at which level the collected information is to be exchanged between the road administrators concerned, and where the centralized information control is to be conducted.

The centralized control of information enables each road administrator to obtain the traffic information of any specific area at any desired time and to monitor the traffic condition in any area with great ease. It is considered that Thailand has already reached the stage where an advanced on-line information exchange system using computers needs to be introduced.

(1) Contents of Information Exchange

Information to be exchanged under the proposed system is classified into traffic control information, traffic congestion information and weather information. The contents and exchange area of each of these three kinds of information are described below.

a) Traffic Control Information

Traffic control information is broadly divided into two types, i.e., the information systematically released and disseminated for traffic regulation to be imposed for the execution of construction work on road surface and the information given promptly for traffic regulation to be imposed immediately after a traffic accident or disaster. It is necessary to determine the exchange area for each type of traffic control information and to exchange with high accuracy all necessary data such as the location, cause, period and contents of traffic regulation as well as detours between related road administrators. If the control information pertains to total passage prohibition, restriction of lane number, duration of traffic regulation or functional division of roads, it needs to be exchanged accurately and thoroughly between all road administrators concerned.

Owing to the increasing speed and converage of road traffic in Thailand, it has now become very important to make a careful study of a control information exchange system that can cover a wider area than before.

b) Traffic Congestion Information

Since daily traffic congestion usually takes place in the same place and in the same time zone, the congestion information service produces little effect. It can be said that what is more important is to diminish the existing congestion by promoting road improvement plans. The daily congestion information service is required more by occasional highway users than by regular and frequent highway users. Since the daily traffic congestion is limited in terms of both location and time zone, the scope of its information exchange need not be very wide.

On the other hand, any sudden congestion caused by a traffic accident or disaster is not predictable and consequently impedes the flow of traffic to a great extent. For this reason, information about sudden congestion always arouses heavy demand from highway users and should be accurately exchanged between related road administrators..

c) Weather Information

In Thailand, weather information is obtained from the meteorological Department's nation-wide forecasting service to give warning and caution to drivers at the time of abnormal weather. However, for satisfactory road administration and to give such weather advice at the time of inclement weather, it is necessary to establish a meteorological observation system using telemetry

units and radar rain-gauges.

The DOH will therefore have to build such an observation system in the future by promoting its construction from areas along national highways to other parts of the country. It will also have to create a system for supplying the collected meteorological data to other road administrators according to need.

(2) Information Exchange System

a) Internal Information Exchange within DOH

The prime objective of the internal information exchange is to enable all internal divisions and sections of the DOH to obtain an accurate, firm understanding of the road condition in their respective control areas and to maintain close communication between the DOH and its local offices.

At present, information collected at local office level is obtained at fairly high speed by the DOH. It is hoped that information collected at the levels of Changwat and Region will be exchanged progressively at high speed for centralized control along with the improvement in the level of road services.

b) Information Exchange between Road Administrators

When any road is closed to traffic owing to an accident or natural disaster, there always arises a strong demand from drivers for information about servicible parallel roads.

To meet such demand, it is necessary to establish a system under which road administrators can exchange relevant information and determine passable routes immediately after the closure of any road. For this purpose, an information exchange manual should be formulated after a careful study of the level or point at which information can be most effectively controlled and exchanged.

c) Information Exchange with Other Organizations

There are many cases where traffic information of various kinds is first reported not only to road administrators but also other organizations such as police and fire stations. It is therefore necessary to build a quick information exchange system linking road administrations and other organizations. This system should be designed specifically for smooth information exchanges between the field officer of road administrators and other organizations because the first reporting mentioned above often calls for emergency action. It is

also important to make these field officers maintain close liaison with each other so that information supplied from them will cause no confusion to the user owing to the lack of data compatibility.

(3) Method of Information Exchange

At present, the DOH has its own microwave communication circuit which is used for information exchange with its local offices. However, it mainly uses telephone lines for information exchange with other road administrators and organizations.

This will retard the exchange of information between road administrators as well as within the DOH where a large number of traffic bottlenecks occur at the same time over a wide area, causing failure to obtain and distribute the necessary information to highway users.

It is therefore recommended that an advanced communication system using private lines and online computers be introduced to achieve total, contralized information control. When a system like this is put into operation, it will eliminate the existing need of information exchange and contribute to quicker and more accurate information communication because all road administrators will be able to obtain the necessary information simply by storing the information they have collected in the data bank.

6.5 CASE STUDY IN CHONBURI AREA

6.5.1 Existing and Future Conditions in Chonburi

Chonburi City is a regional center about 90 kilometers eastwards on Route 3 from Bangkok. The Chonburi area is situated at the entrance to the eastern coastal region and has achieved rapid growth in recent years owing to the progress of such industrial park construction projects as Lane Chabang and Rayong. Located mid-way between Bangkok and the international resort of Pattaya, the city has also been long known as an important transportation point. Figure 6.2 shows the current road network in and around Chonburi City.

Route 3 (four lanes) runs north to south through the city, with a semi-circular bypass (two lanes) branching off the route to allow drivers to detour around the city. Heavy vehicles other than sightseeing buses are required to use the bypass for the purpose of maintaining smooth traffic flow within the city.

This measure alone, however, appears to be inadequate for achieving smooth flow, because Route 3 is lined with movie theaters, hospitals, schools and other facilities that attract a heavy volume of traffic. Moreover, a large number of vehicles cross Route 3 in an east-west direction in order to reach service establishment that are located long local streets running parallel to Route 3. Thus, major intersections within the city cause bottlenecks on Route 3.

In consideration of the above situation, the DOH is currently pursuing a plan to add two new lanes to the bypass. Figure 6.3 shows the current and future volumes of traffic in the Chonburi area. As indicated by the results of a survey conducted by the JICA Study Team, Figure 6.4 gives the locations of traffic signals in the area, together with travel times between major intersections.

6.5.2 Purpose of Case Study

The purpose of the subject case study is to give a specific example of the initial considerations for a traffic information system discussed in Section 6.3. The case study also attempts to obtain information necessary for formulating a Master Plan, by estimating the expenses required to install the indicated traffic information system.

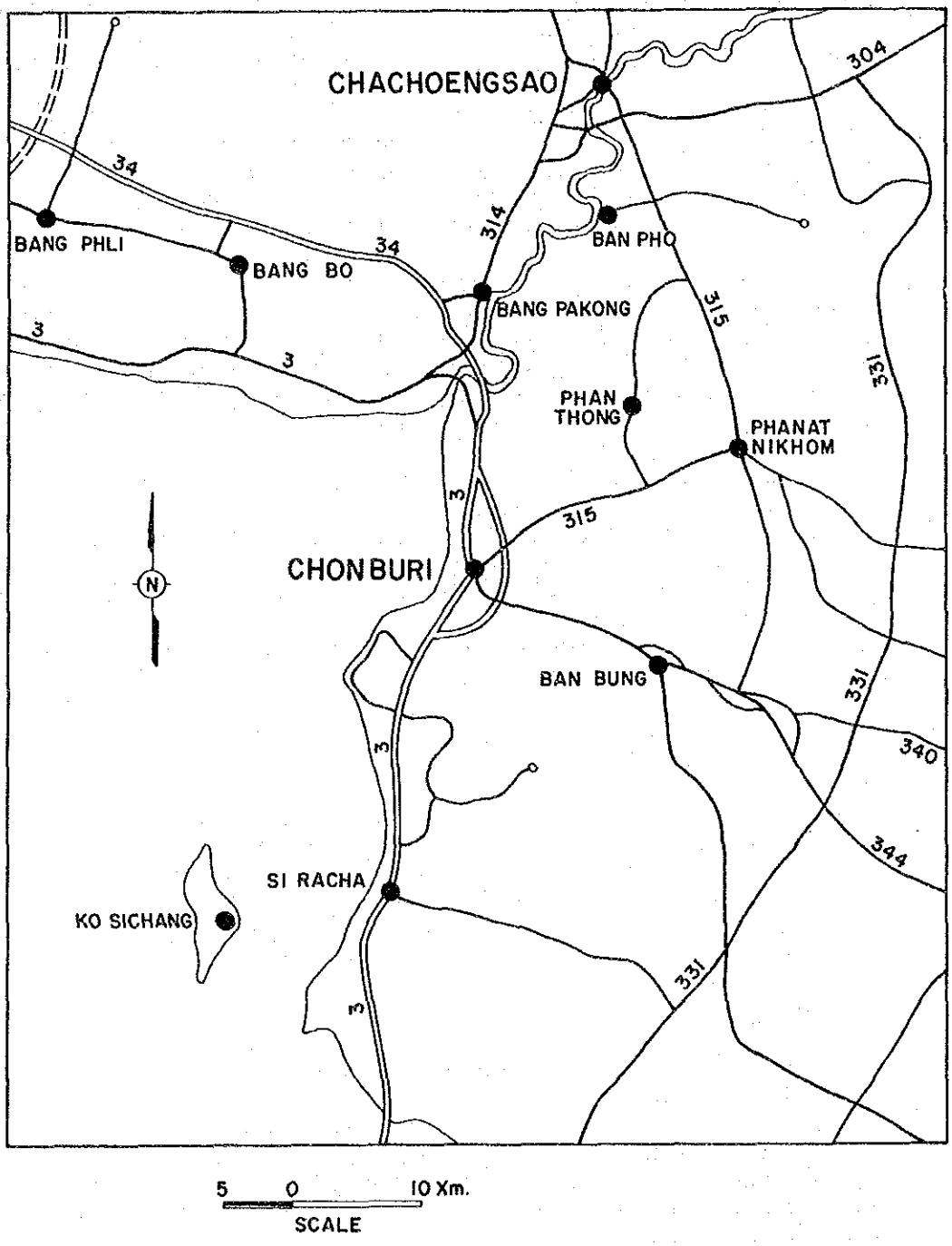


Figure 6.2 Road Network in and around Chonburi City

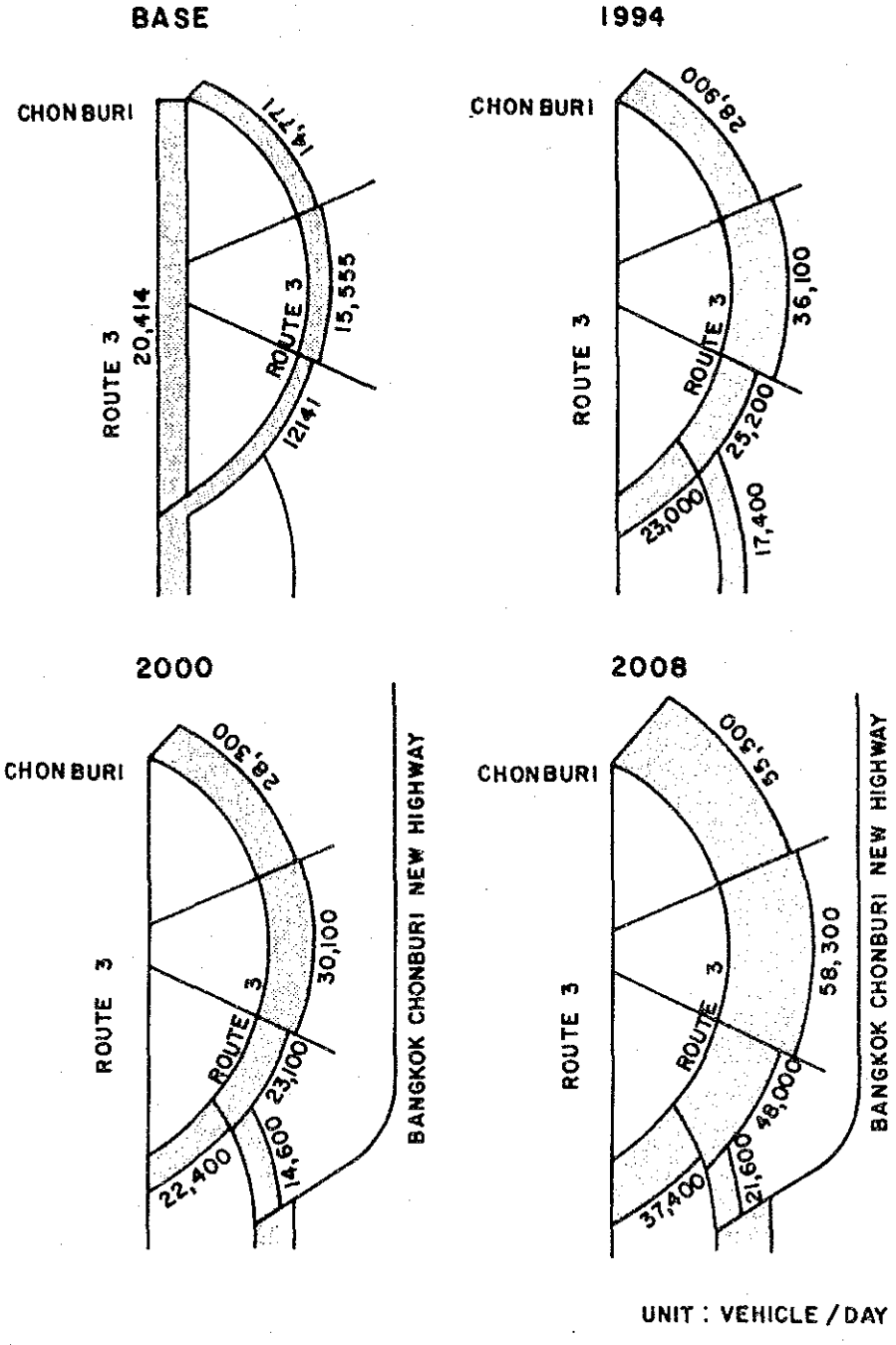


Figure 6.3 Current and Future Traffic Volume in Chonburi Area

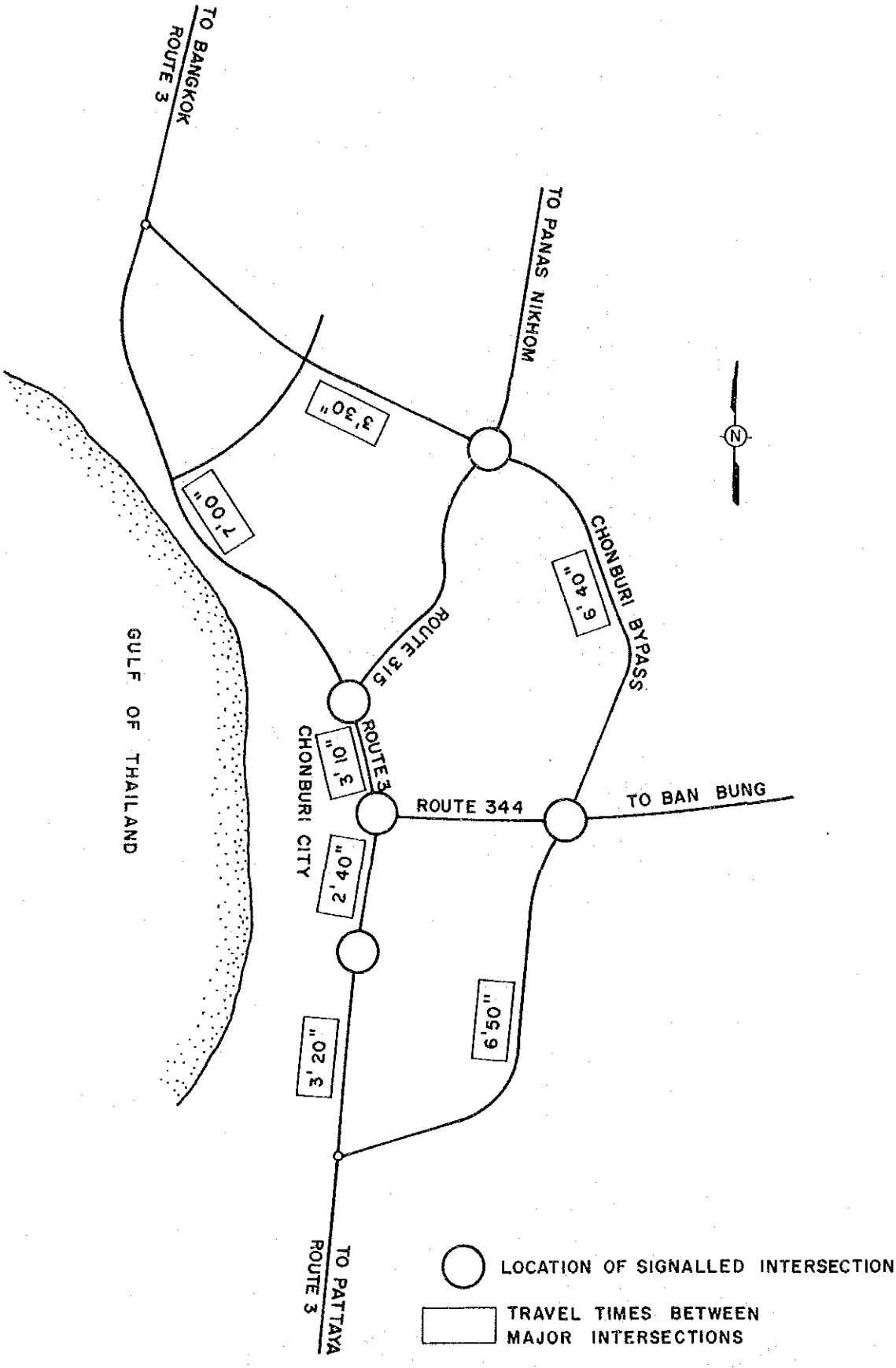


Figure 6.4 Traffic Signal Distribution and Travel Time in Chonburi Area

The traffic information system that the Study proposes for the Chonburi area consists of vehicle detectors for evaluating traffic conditions and variable message signs for transmitting traffic information to drivers. The control center will be located in the Chonburi District Office for the time being.

6.5.3 Outline of Case Study Plan

(1) Software Configuration

The software system configuration is shown in Figure 6.5. Traffic information obtained from vehicle detectors will be used as primary data, and those obtained from ITVs, patrol cars, telephones and monitors will serve as patrol cars, telephones and monitors will serve as supplements.

Data on traffic volume and time occupancy will be obtained from vehicle detectors, and travelling speed will be calculated from the traffic volume and occupancy thus obtained. While it is possible to have detectors input information at intervals of 30 seconds, 1 minute, 5 minutes or 15 minutes, the interval assumed for the subject system is 5 minutes, in consideration of such factors as the scattering of data.

In general, one of the following three types of traffic information is compiled and transmitted on the basis of data collected from vehicle detectors: queue length, degree of congestion, and travel time. For the subject system, travel time is proposed as the information most desired by drivers, based on the needs survey conducted at the Don Muang Airport.

(2) Hardware Configuration

The hardware system configuration is shown in Figure 6.6 The planned layout of the various equipment and devices is shown in Figure 6.7.

Terminal equipment consists of vehicle detectors, message signs, and ITVs. Since the ultrasonic vehicle detector is superior in terms of ease of construction and maintenance, this type is suggested for the subject system. A pattern-selection message sign instead of a, free-pattern sign is proposed for the subject system, since only a few kinds of information are to be provided, added to the fact that the messages to be transmitted are relatively fixed. Overhead message signs will be provided at major locations and roadside signs at supplementary locations. Figure 6.8 shows the shapes of these two types of signs.

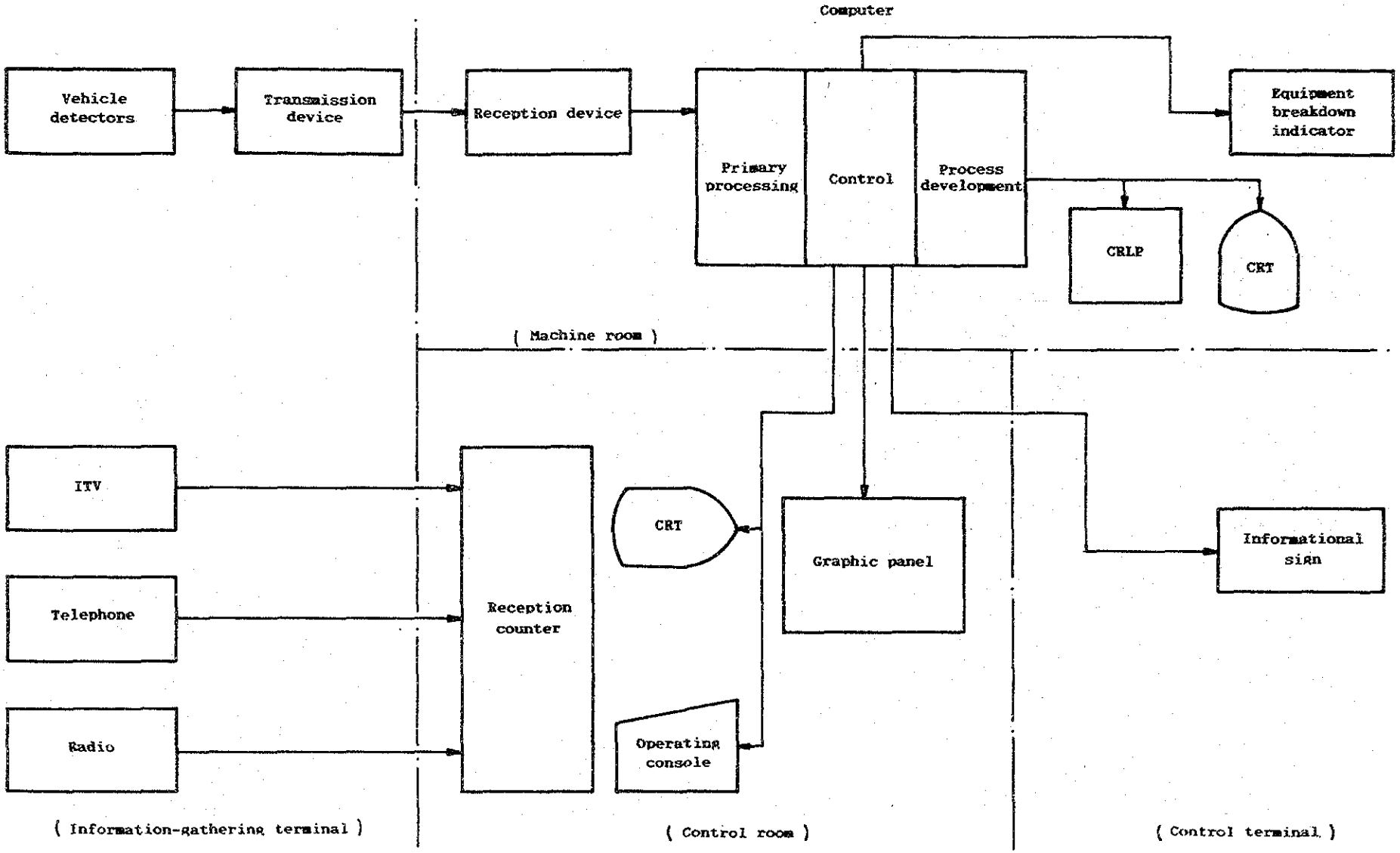


Figure 6.5 Software System Configuration

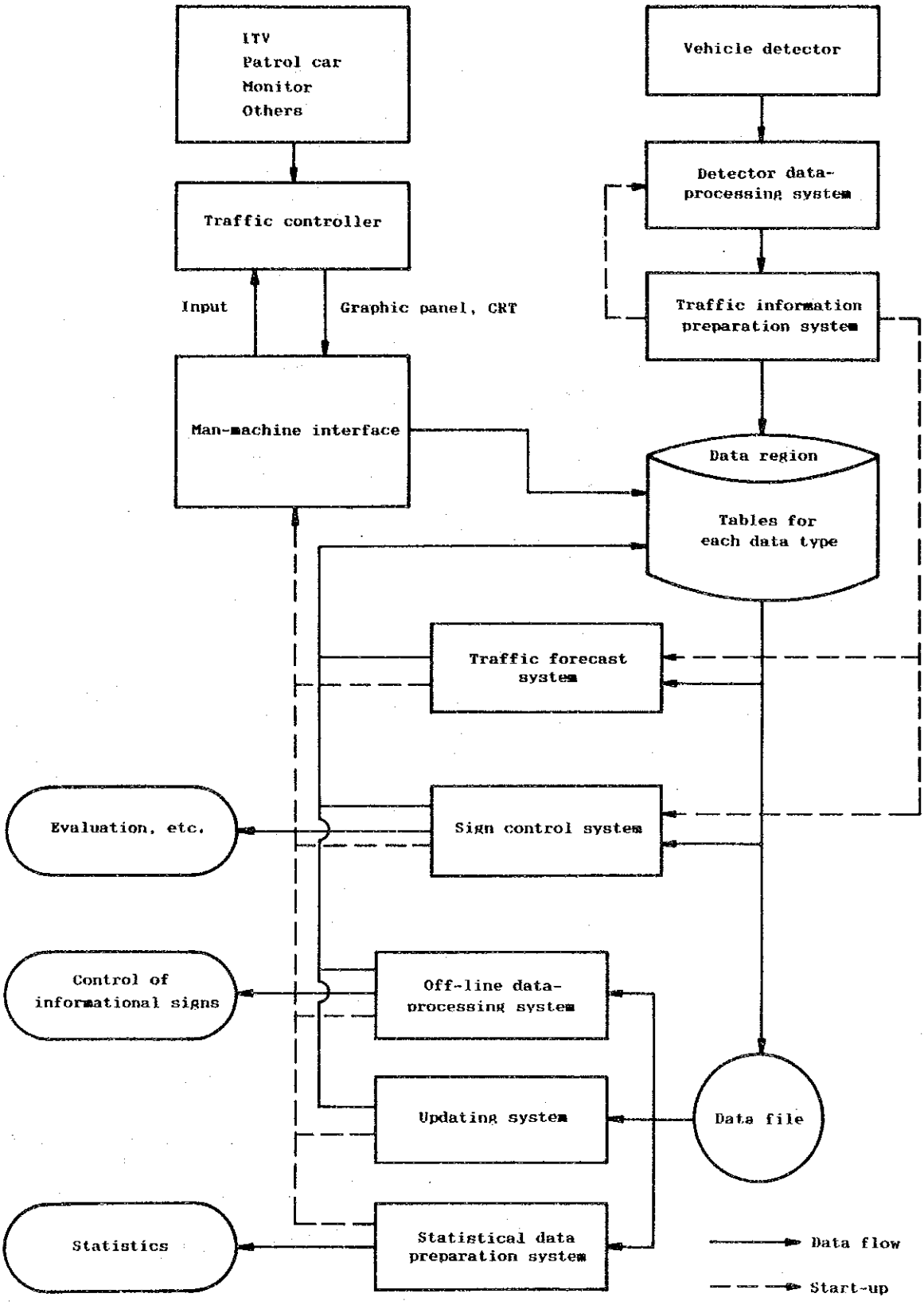


Figure 6.6 Hardware System Configuration

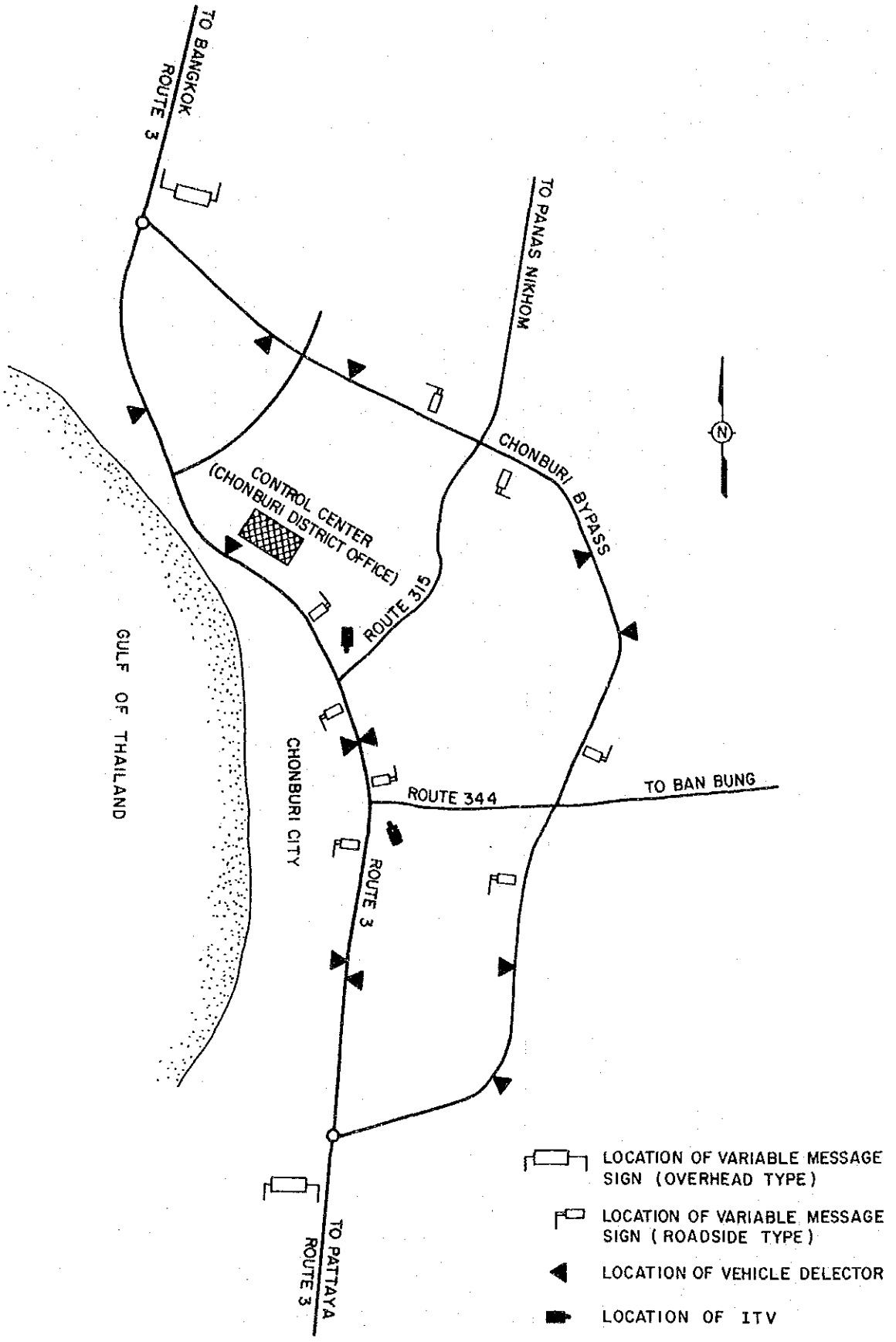
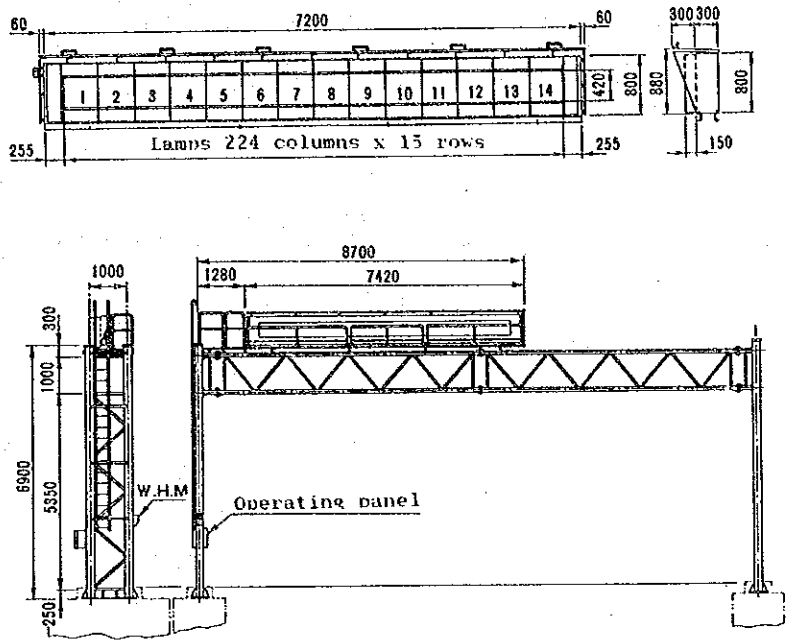


Figure 6.7 Traffic Information System Plan for Chonburi Area

1) Overhead Type



2) Roadside Type

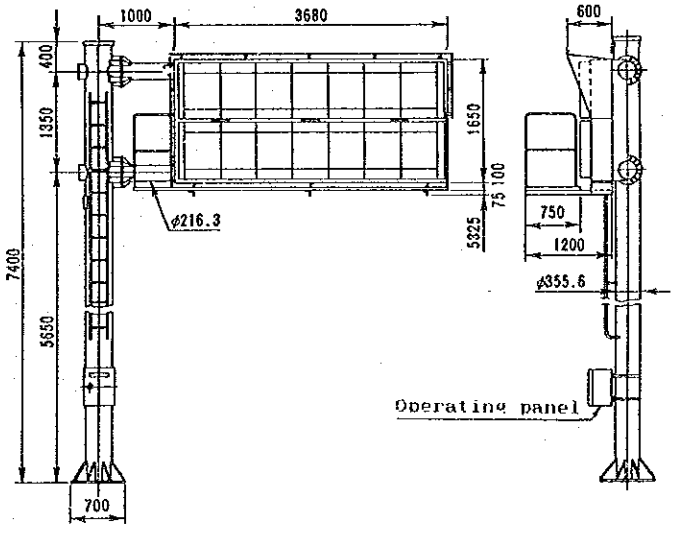


Figure 6.8 Message Signs

Equipment to be housed in the control center consists of a computer, operating consoles, CRTs, and a graphic panel display. The capacity of the computer should be determined after carefully studying the software algorithms, but it is estimated that a core capacity of 15 kilobytes and disc capacity of 1 Megabytes are adequate.

(3) Conceptual Sketch of Traffic Information System

The basic concept in implementing the proposed traffic information system for Chonburi area may be sketched in Figure 6.9. The planned layout of the control center is shown in Figure 6.10.

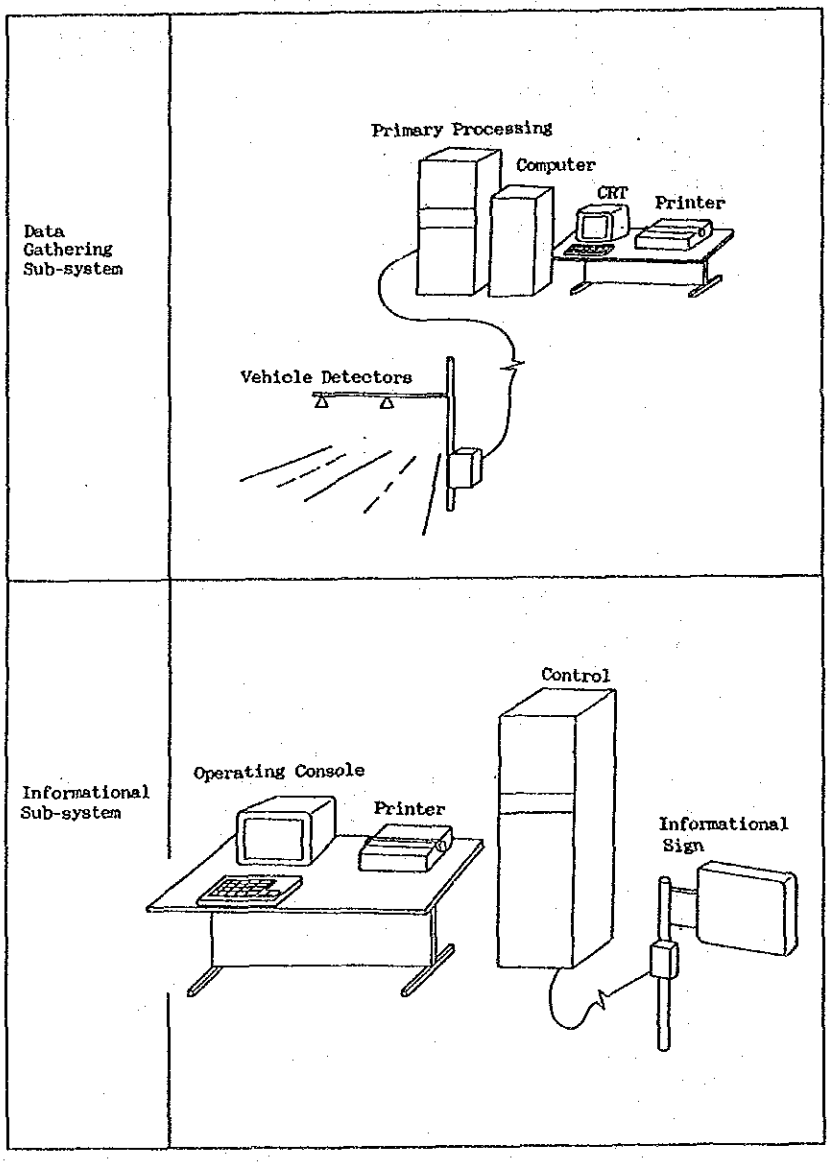


Figure 6.9 Conceptual Sketch of Traffic Information System

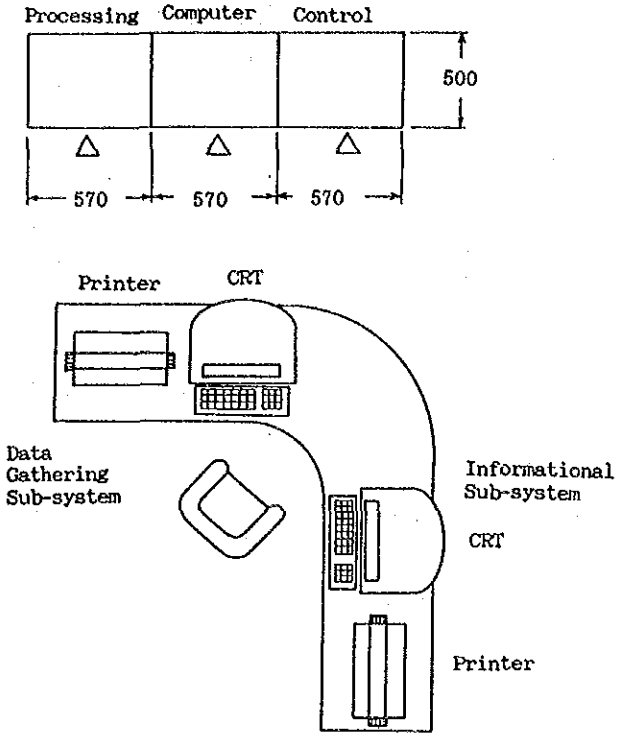


Figure 6.10 Layout of Control Center

CHAPTER 7 ROAD INVENTORY SYSTEM

CHAPTER 7 ROAD INVENTORY SYSTEM

7.1 OBJECTIVES OF ROAD INVENTORY SYSTEM

In order to manage road systems adequately and carry out essential engineering measures on roads, availability of information on the road conditions is of great importance to road administrators. Objectives of this part of the study are to formulate a comprehensive development plan of the road inventory system which puts emphasis on an interface for traffic engineering works for national highways within the jurisdiction of the Department of Highways.

There are several types of the road inventory systems within DOH. The biggest one was established in 1984, with the aid of main frame computer (Burroughs A3K Model), and source data for this database has been collected by computer section in DOH; however, some detail data are not yet available. Other systems are maintained by the Traffic Engineering Division itself, with the aid of microcomputers, on traffic engineering subjects such as on traffic accidents, traffic volume, etc.

Existing computerized database system do not seem to be sufficient to cope with the ever increasing social demands as to road traffic management, by the shortage of maintenance methods on data collection, on to inter-link the data between other databases and management method on increasing road network. The road inventory system should be employed with particular attention such that DOH staff can easily maintain the database, and can readily access information essential for daily management works such as traffic facility plan, safety plan, maintenance and administration of roads.

The Road Inventory System is formulated in such a way that inventory database supplies necessary data for the traffic engineering works on road geometry and conditions, and data items of the database can be interfaced to make better use of collected data on the existing road database in DOH. It should be noted that the Road Inventory System in this study is recommended so as to realize the actual use within five years in consideration of the feasibility on technical and management affairs for the system.

7.2 EXISTING DATABASE SYSTEM IN DOH

7.2.1 Hardware and Software

(1) Main Frame System

The Burroughs computer 1825S was initially introduced for the database task for DOH in 1982. This machine has ample disk storage capacity and adequate operating speed, and is supported by system software which facilitate the database task. With increasing use of computerized information systems, a new Burroughs A3K machine of better performance replaced the older one's in 1985. The new system has a central process capacity of 12MB and of an external disk capacity of 2.6GB as shown in Figure 7.1.

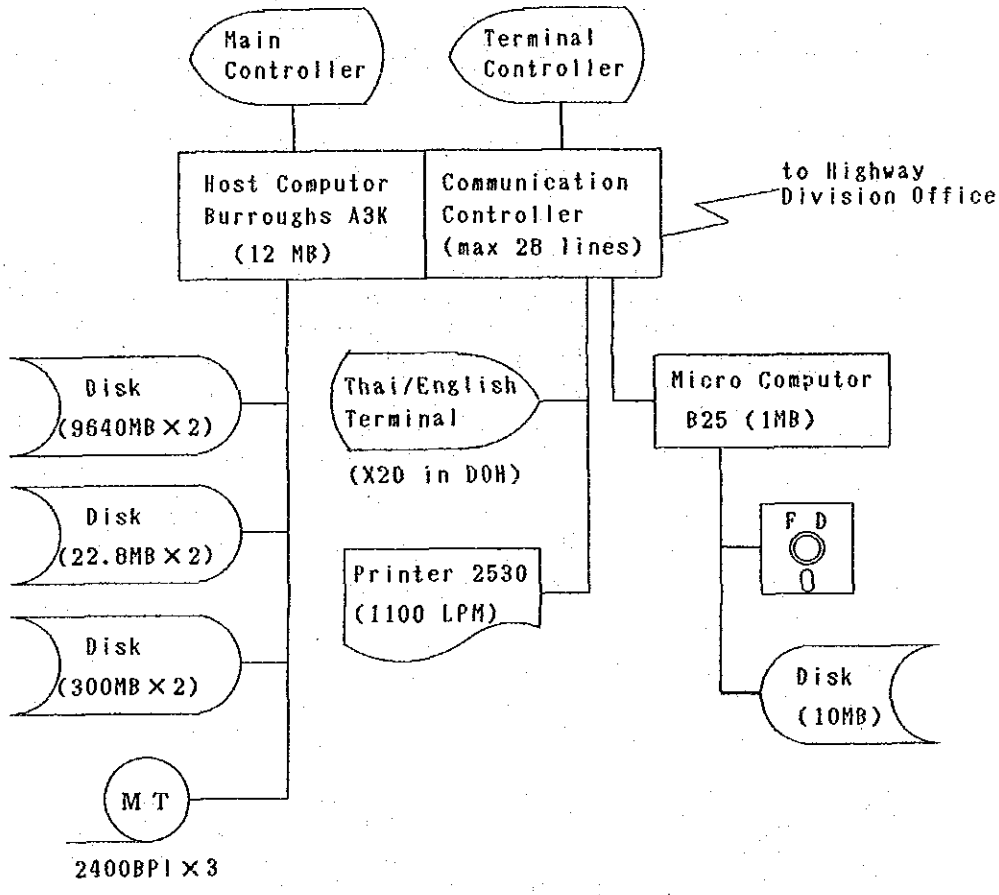


Figure 7.1 Burroughs A3K System

In order to take full advantage of the Burroughs A3K's effectiveness in data storing and processing, available system software are installed as follows;

Operating System : MCP,

Language	: COBOL, FORTRAN77, PASCAL, PL/1, ALGOL60, BASIC and PRGIII.
Database Management System;	DMSII and LINC.

DMSII is a relational type database management system, and the database established by DMSII is accessed by an application program written in COBOL language or LINC which is the one of fourth generation languages to process database efficiently.

(2) Microcomputer System

A few microcomputer systems are used for traffic data processing in TED. However, no microcomputer has been introduced other than TED in DOH office as well as district office. Microcomputers in TED are utilized daily in works and annual data compiling and processing of traffic engineering works.

Associated software in the above machine are MS-DOS in Japanese version for operating system and NBASIC for application software for data processing.

7.2.2 Communication Network

The host computer B-A3K in Computer Section in DOH connects twenty sets of intelligent terminals in DOH head office and through the telecommunication controller, fifteen sets of intelligent terminals are connected to the host machine through a public telephone line from each division office of DOH as shown in Figure 7.2. Transmission speed is 1,200 BPS which is insufficient to operate the center-local database systems between center and local offices.

There are three types of terminal machine as shown in Figure 7.3, although each terminal has functions both from local terminal between host machine, and on an independent microcomputer from the host computer.

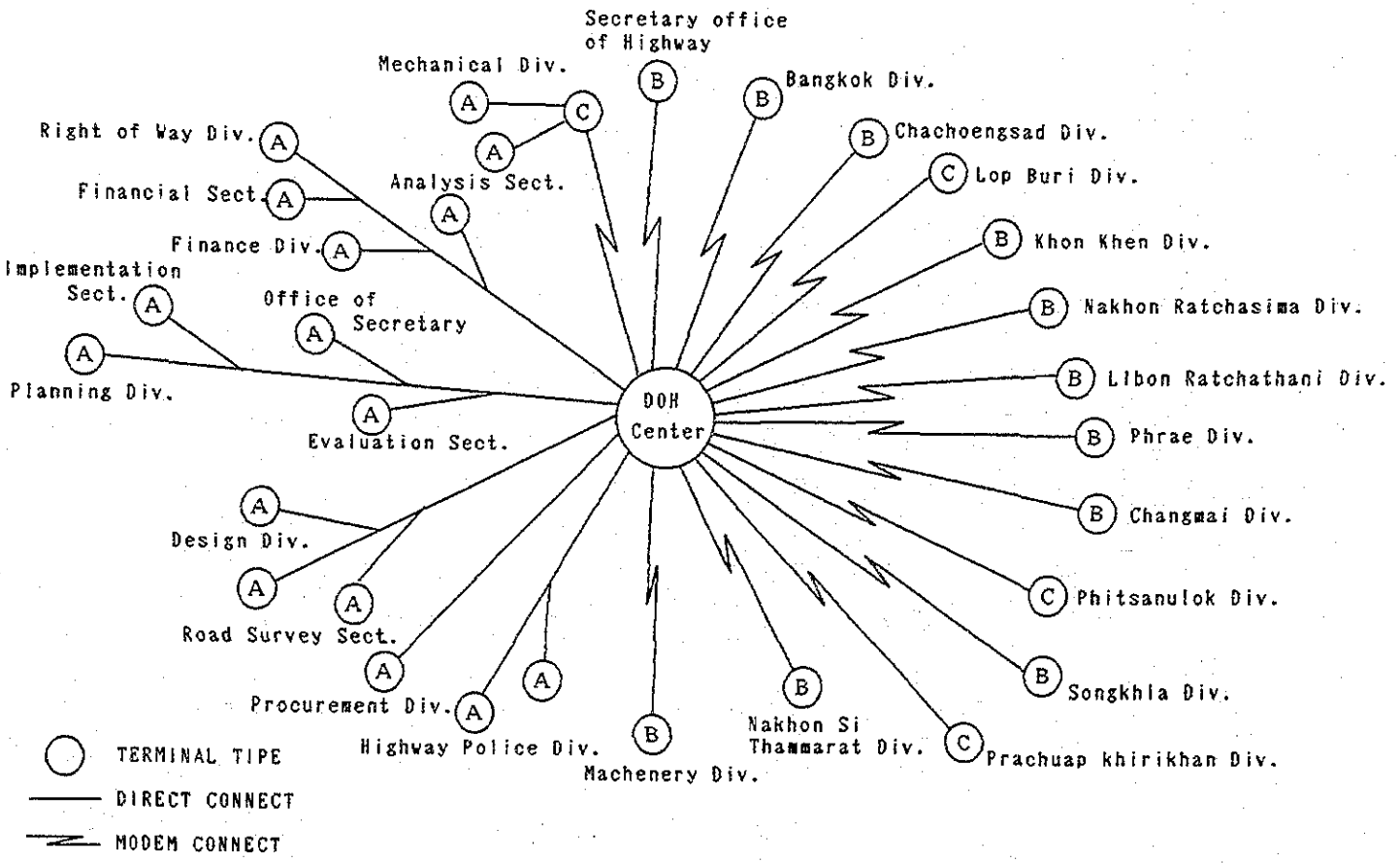


Figure 7.2 Communication Network for B-A3K System

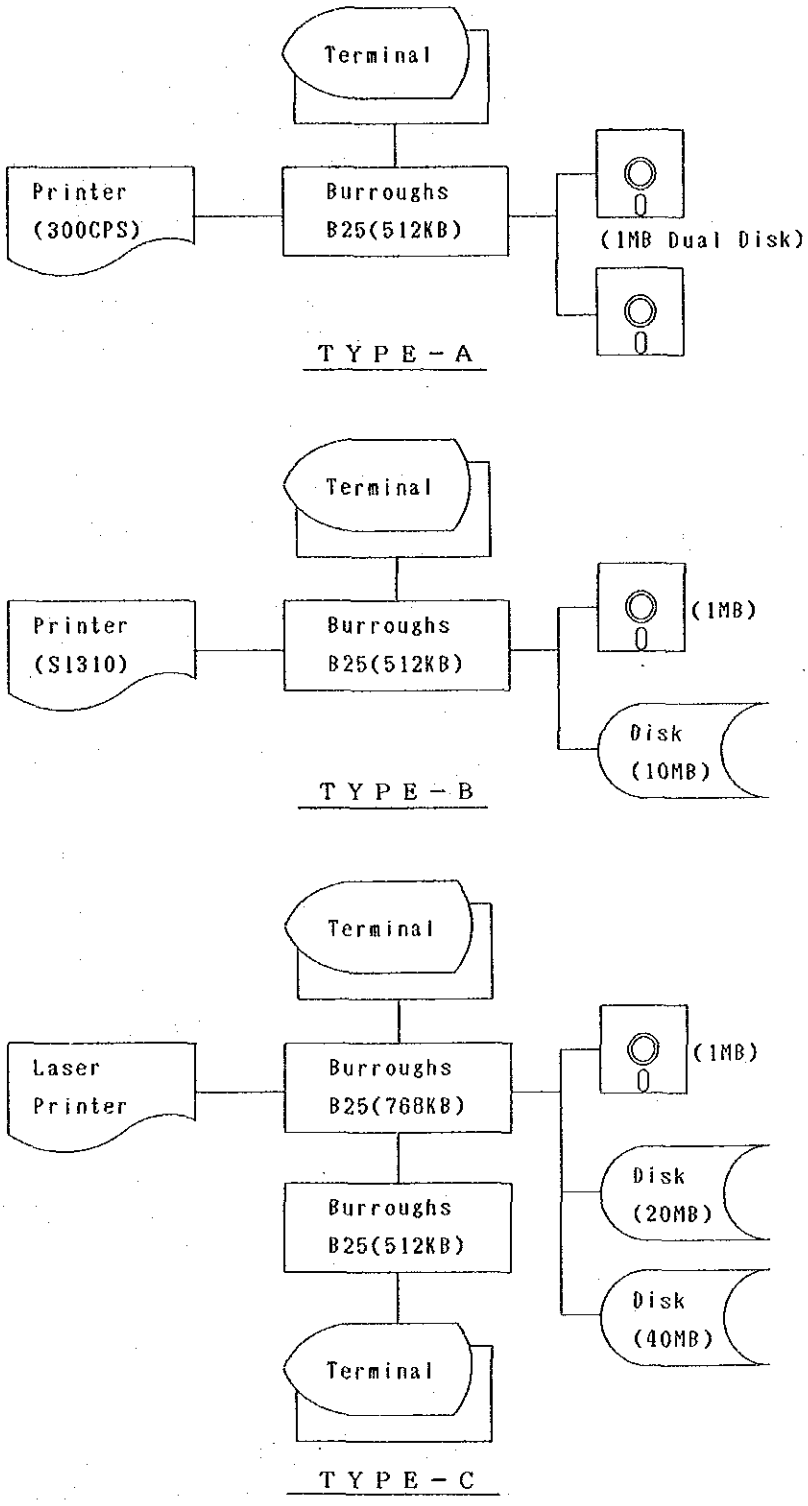


Figure 7.3 Remote Terminal Devices of B-A3K System

7.2.3 Databases in Main Frame System

(1) Types of Database System.

The nine existing databases relevant to roads are compiled in B-A3K system as listed in Table 7.1. The first three databases in Table 7.1 are used for daily works in traffic engineering in TED.

Table 7.1 Existing Databases in B-A3K System

Database System	Established by	Established Year	Data Volume	Remarks (DBMS/Language)
Road Database	Planning Division	1984	150 MB	DMS II / DASDL
Traffic Volume	Traffic Eng Division	1982	3 MB	Seq.Fl / Fortran
Traffic Accident	Traffic Eng Division	1988	3 MB	ISAM / Cobol
Construction Project Information System	EDP Office	1988	414 KB	DMS II / LINC
Construction Project Planning System	EDP Office	1989	305 KB	DMS II / LINC
Maintenance Database	Maintenance Division	1988	2.1 MB	DMS II / LINC
Machine System	Equipment R/F Office	1986	3 MB	DMS II / LINC
Personnel Database	Personnel Division	1983	22 MB	Data Structure / Cobol 74
Highway Police Personnel Database	Personnel Division	1988	315 KB	DMS II / LINC

a) Road Database

These were developed by VLD Road Feasibility Studies Training Project Team in 1984. Database consists of fourteen database files with approximately three hundred and fifty items of data in total. Source data is gathered by Data Preparation Section for the entire national highway system in Thailand.

b) Traffic Volume Database

Database on annual average daily traffic volume(AADT) which is collected at about 2,200 locations on national highway three times each year. TED obtains source data for daily work from this database.

c) Traffic Accident Database

Database on traffic accident on national highway is collected by local police and highway police.

(2) Road Database System

The existing road database, which has established in 1984, is commonly used for several kinds of road administration works and maintained by related sections within DOH other than TED as follows;

Planning Division,
Maintenance Division,
Material and Research Division, and
Location and Design Division etc.

The road database consists of fourteen database files as listed in Table 7.2. After developing the database system in 1984, source data had been gathered to establish the database initially mainly by computer section in DOH. As a result, the whole database file was based on the current data. However, only a few database files on control link, traffic accident and traffic volume are periodically updated.

Table 7.2 Database Files of Road Database

Name of Database File	No. of Items	Record Length (Bytes)	No. of Records	Remarks
Control link	150	630	2,500	Updated
Horizontal Alignment	12+11*12=144	34+50*12=634		Not available
Vertical Alignment	8+7*8= 64	33+28*8=257		Not available
Accident Data	8+8*8= 72	26+21*8=199	2,000	Updated
Intersection	6+5*6= 36	20+25*6=170	3,600	Updated
Railway Crossing	6+4*6= 30	20+37*6=242		Not available
Bridge	6+14*6= 90	20+50*6=320		Not available
Culverts	6+6*6= 42	20+16*6=116		Not available
Ferries/Floodways	6+3*6= 24	20+12*6= 92		Not available
Flooding History	8+7*8= 64	27+27*8=243		Not available
Socio-Economic Data	6+4*6= 30	20+32*6=212		Not available
Utilities	6+5*6= 36	20+20*6=210		Not available
BNKLMN BM Deflection	9+4*6= 33	26+22*6=158		Not available
Construction Materials	6+3*6= 24	20+13*6= 98		Not available

(3) Maintenance of Road Database

Maintenance works for the road database system are comprised of data updating and maintenance for the system. In addition to the scanty utilization, it seems that the insufficient level of data maintenance resulted in reducing the reliability on data and serviceability of the system. Data maintenance works are necessary for the following items;

a) Road Network

Road database system is designed in such a way that append new data records for new control links and alter old data records into correct ones, and delete information stored in a database for modification of road network. These tasks should be both systematically and periodically implemented in terms of effective utilization by users.

b) Data Collection and Checking

How, when and by whom should the new data be collected and the old data which is to be superseded ?. Some objective data for the system have to be collected through many sections within DOH. Checking the data is essential to compile the correct data into the database.

(4) Utilization of Road Database

Data stored in the road database are effective to grasp the general road condition, however, seem not to be sufficient enough to cope with ever increasing engineering demands as to road traffic management. Major defect against the better use was caused by the shortage of data items essential for traffic engineering such as detail data on roadway, intersection and appurtenances of road. Others are due to both lack of data to be stored and duplication of data records caused by deficient data maintenance.

7.2.4 Databases in Microcomputer System

Ten databases in the microcomputer system, which are owned in TED, are currently established and used for their works by staff in the office, as shown in Table 7.3. However, due to a shortage and/or duplication of essential data, it seems that no effective use would been accomplished for traffic engineering works other than statistics processing on traffic volume and accidents.

Table 7.3 Databases in Microcomputer System in TED

Kinds of Database	Lunguage	Data Volume	Est'ed Year	Updated Interval	Remarks (Usage)
Accident from DOH	NBASIC	3300 Rec	1984	Yearly	Traffic Accident
AADT in Thailand	NBASIC	2200 Rec	1985	Yearly	Traffic Volume
Accident from Local Police	NBASIC	600 Rec	1989	2-3 Year	Traffic Accident
Weight Facter	NBASIC	500 Sta	1986	Yearly	Traffic Volume
Traffic Station	NBASIC	2200 Sta	1986	Yearly	Traffic Volume
Control Section	NBASIC	2600 Sta	1985	Yearly	Traffic Volume
Hazardous Location	dBASE II	300 Sta	1987	Yearly	Traffic Volume
Permanent Station	NBASIC	30 Sta	1986	Yearly	Traffic Volume
Traffic in South Area	NBASIC	400 Sta	1988	Yearly	Traffic Volume
Omron	NBASIC	1 Sta	1985	Yearly	Traffic Volume

7.3 SYSTEM ANALYSIS

7.3.1 Database for Traffic Engineering

(1) Data Items

Road inventory system will be commonly used for traffic engineering to assist management and planning works as follows;

Management Works; grasp of existing states, traffic management/operation, traffic facility maintenance and administration

Planning Works ; budget planning, traffic safety planning, traffic facility planning and road improvement planning.

The road inventory system for traffic engineering will be designed particularly such that DOH staff can readily access information essential for daily management works such as planning, maintenance and administrative works of national highways. The data to be included in the road inventory would cover information on roadway, intersection, traffic facilities, traffic volume data and traffic accident data.

These data items, which are described in Figure 7.4 by classified group for traffic engineering use, were discussed with counterparts in detail in view of traffic operation, management, planing and administrative works in TED in addition to the traffic census system. The details of items, which sufficiently cover the existing road database, are presented in Appendices as data fields of road inventory database.

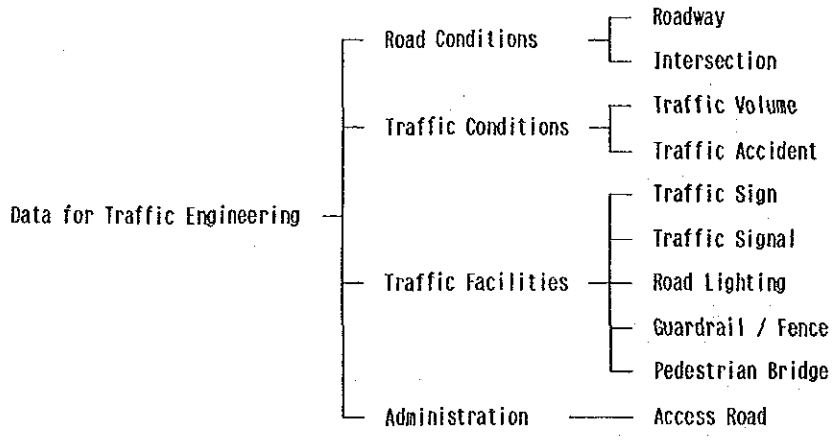


Figure 7.4 Data Group for Traffic Engineering

(2) Database Files

Based on the discussion with TED's staff, eleven database files are tentatively decided for the road inventory system in traffic engineering as shown in Table 7.4. These database files include almost all data essential for traffic engineering for the purposes of management and planning works. Database file for access roads, which is under the jurisdiction of TED, will be used to admit and to manage them to an applicant.

Table 7.4 Database Files for Road Inventory System

Database Files	Current Conditions	Remarks
Control Link	Exist in Road Database	Improved to append new data items for more detail and wider traffic engineering use
Intersection	Exist in Road Database	Improved to append new data items for more detail and wider traffic engineering use
Traffic Volume	Exist in B-A3K System and Microcomputor System	Improved to compile effectively for wider use and better data maintenance
Traffic Accident	Exist in B-A3K System and Microcomputor System	Improved to compile effectively for wider use and better data maintenance
Traffic Sign	Not Exist	Newly formed for traffic engineering use
Traffic Signal	Not Exist	Newly formed for traffic engineering use
Road Lighting	Not Exist	Newly formed for traffic engineering use
Guardrail/Fence	Not Exist	Newly formed database for facility management
Pedestrian Bridge	Not Exist	Newly formed database for ristricted conditions by pedestrian bridge
Access Road	Not Exist	Newly formed database for administration works of TED

(3) Key Identifiers

Generally, database files are similar to the table which consists of columns and rows as shown in Figure 7.5. Columns are called a field which corresponds to the data items, and rows are called record which corresponds to one collection of data belonging to a common key identifier, such as one control section in control section database file.

	Key Identifiers				Attributive Data			
Record 1	Field 1	Field 2	....	Field N	Field N+1	Field N+2	....	Field N+K
Record 2	Field 1	Field 2	....	Field N	Field N+1	Field N+2	....	Field N+K
:	:	:	:	:	:	:	:	:
Record M	Field 1	Field 2	....	Field N	Field N+1	Field N+2	....	Field N+K

Figure 7.5 Structure of Database File

A record is distinguished by key identifiers which specify a given data record from other records in the database file. The whole database file for traffic engineering possesses several items as key identifiers at the head of each record as shown in Figure 7.5. Consequently, every record has a particular key identifiers to access and extract the data from the database.

A control section is a main item which defines a record by means of a key identifier. In addition, other key identifiers should be chosen in consideration of the effective computer usage and in easier maintenance works by users.

7.3.2 Road Network

(1) Control Section System

For the purpose of describing the road system, it will be subdivided into 5-20km. segments and within each segment characteristics can be considered to be homogeneous. These segments correspond to the control section which have been DOH's standard identifiers of road segments. The identification of each road segment described in the database is by means of its Control Section Number (CSN), which has the general 11- decimal-digit form as follows;

RDd rrrr ccss

where,
- R; DOH region in which the segment is located,
- D; maintenance division,
- d; maintenance district,
- rrrr; 4-digit route number,
- cc; 2-digit control section number,
- ss; 2-digit subsection for control section number.

As a result, the number of control sections at present is approximately 2200, which means that average length of one control section is 22km. throughout the total national highway system in Thailand. For practical purposes such as the higher and more detailed utiliza-

tion of stored information in the database, identification of road segments should terminated exactly at the border of districts, at abrupt change points of road geometry and at the major intersections including those with major rural and municipal roads. However, the current control section system does not have sufficient capability to subdivide the existing control section into two or more control sections as necessitated for traffic engineering use.

(2) Management of Road Network

As it is necessary to manage key identifiers of the database with the growth of road network, the road database is structured in such a way that it is possible to;

A. Add a new control section and its associated data.

B. Delete existing control section.

C. Alter the identifier for a control section.

D. Split an existing control section into two or more new control sections.

E. Combine two or more existing control sections into a smaller number of new control sections.

The existing control section system is sufficient enough to manage information in view of land and/or road development planning. However, a further identifier for road segments is necessary in the traffic engineering in addition to the existing one, while leaving the existing identifiers as they are to link the data between new database and to use the existing database for current works.

In addition to the improved identifier, it is essential to provide the improved maintenance methods on modification of road network and on relationship between kilometer post and chainage of the highway.

7.3.3 System and Operation Analysis

(1) System Inter-relations

An existing road database is to be maintained separately from the road inventory system in the same way as at present. However, it is necessary to update and maintain the road inventory database by TED as shown in Figure 7.6. Meanwhile, check and/or exchange functions will be essential to ensure there are no inconsistencies on the same data items between the both databases.

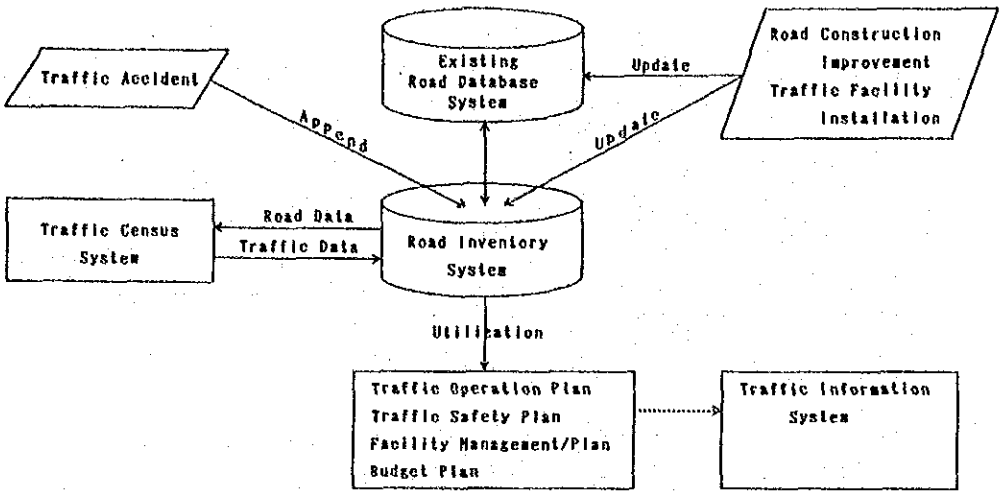


Figure 7.6 Illustration of System Inter-relations

The road inventory database provides data on planning for traffic survey of census system. And analyzed data of census system will be used to update data on traffic volume of road inventory database.

The database interrogation language provides a wide variety of utilization for traffic engineering such as operation plan, safety plan and selection of priority area for traffic information system.

(2) System Gradation

Nowadays, it is technically possible to build up the fully computer aided information system by the recent remarkable progress on computer technology and communication technology. Figure 7.7 presents the basic image of the advanced information system which is independently operated by both the center database and local database maintained in the district office. Center data-base stores information essential in country wide traffic engineering tasks such as operation plan and budget plan etc., while the local database compiles the detail data on facility management governed within each district office.

The above mentioned fully computer aided system requires time to develop and to train operators. There are also hardware costs and the resources costs to maintain the system as well. For this reason in developing the advanced system in road related authorities in Japan, in addition to the computerized inventory system, a written inventory system was also used together with the former system as shown in Figure 7.8. Another reason using the written inventory system is that only the district office needs the more detailed information to construct and maintain road facilities within their jurisdiction.

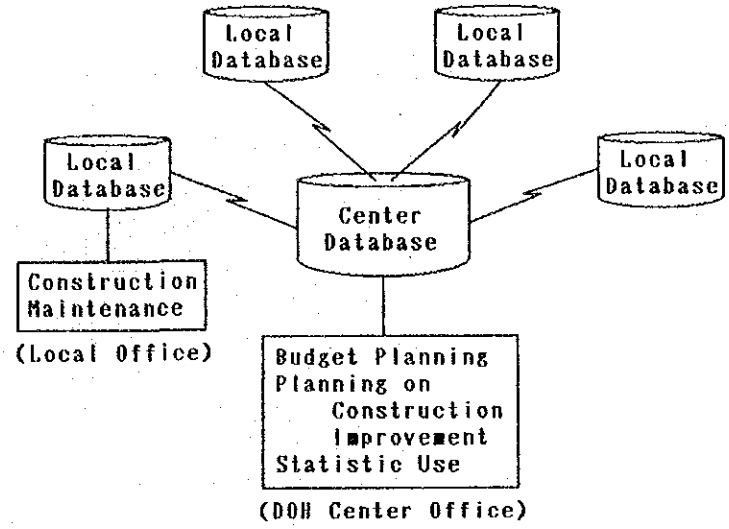


Figure 7.7 Center/Local Database System

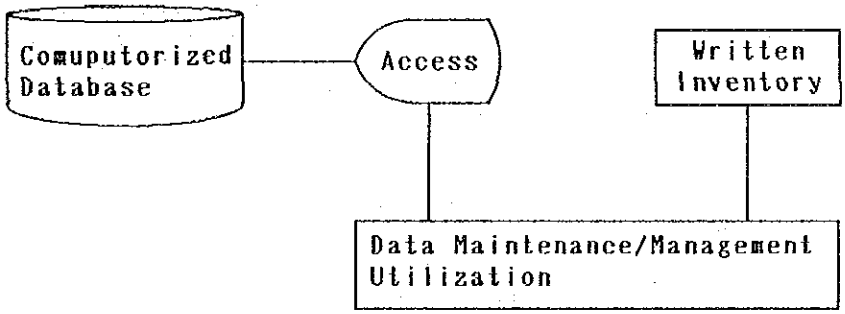


Figure 7.8 Computerized and Written Inventory System

(3) Data Gradation

The level of detail of stored data is of great importance in formulating the information system. An excessive level of data detail stored in database, will result in excessive workload for data collection and maintenance, while a simpler level of data will not be able to supply sufficient information in utilization of database to users.

There are two kinds of detail in the level of data. One is on the level of detail on the identification method of data record which are presented in key identifiers in each record as shown in Table 7.5. Another is on the level of detail on associated data items which are mainly affected by the practical utilization methods of stored information in the database.

(4) Function of Road Inventory System

Interface programs which provide input, error checking and output, should be prepared for daily use of inventory system as shown in Figure 7.9.

Table 7.5 Data Gradation of Road Inventory Database

Name of Database	Data Gradation by Rough ⟷ Detail
Control Section	District / Change of Geometry / Intersection with DOH Road / Intersection with Rural Road
Intersection	Intersection with DOH Road / Intersection with Major Rural·Municipal Road
Traffic Volume	Control Section / Survey Spot / Survey Time
Traffic Accident	Control Section / Roadway·Intersection / Accident
Traffic Sign	Control Section / Roadway·Intersection / Pole / Board
Traffic Signal	Signaled Location / Pole / Face
Road Lighting	Control Section / Roadway·Intersection / Type of Light / Pole
Guardrail/Fence	Control Section / Type of Guardrail·Fence
Pedestrian Bridge	Control Section / Pedestrian Bridge / Span
Access Road	Control Section / Access Road

The input interface program enables the updating of the superseded data by direct key-in to the display screen. The check interface program points out incorrect data such as wrong coding in code items and unsuitable numerical value data. It also points out a mismatch of data between database of the new road inventory and existing road database. The output interface program consists of two components supporting output processes. One enables prompt retrieval of data items in frequent use and to output in the standard inventory forms, while the other supplies a wide variety of output for the wider traffic engineering utilization.

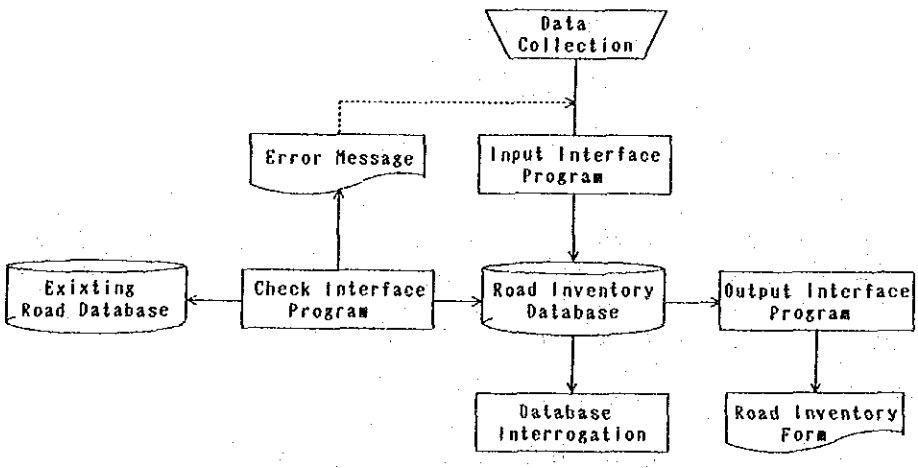


Figure 7.9 System Flow

(5) System Operation

Almost all the effort of system development should be focused on easy access by users. As a result, operation of the system should be designed in such a way that users can operate the system by responding to the query statements shown on the computer display for daily use such as output and data maintenance. Figure 7.10 shows the basic operation flow for the road inventory system.

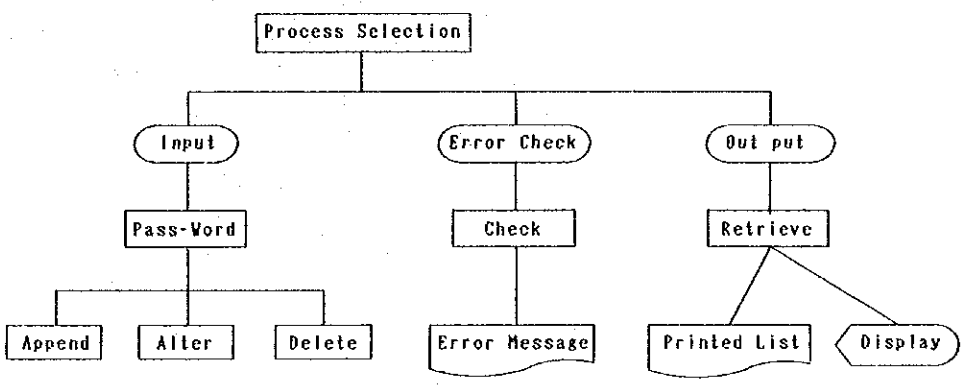


Figure 7.10 Operation Flow

As skilled computer operators are in short supply both in center office and as well as local office in DOH, in order to readily maintain road inventory database, it is essential to prepare support functions on operation as follows ;

1) Password

To protect the data base from inputting erroneous information and mishandling, only the correct password can trigger the opening of the designated process such as appending, altering and deleting.

2) Error message

To prevent compiling incorrect data into the database, the system provides an appropriate error message against any unsuitable input data.

Even if the above mentioned support function assists the establishment of road inventory database, it seems that the wider use by means of database interrogation software is limited in operating by TED staff itself.

7.4 SYSTEM FORMULATION

7.4.1 Principles for System Formulation

(1) Formulation Procedures

A formulation plan for the road inventory system, which will be newly developed for the traffic engineering use, will include an improvement of the existing database system and addition of supplemental information for traffic engineering as well as system functions to achieve the effective utilization by users. In order to implement the system, system formulation should be generally implemented in consideration of the feasibility based on technical conditions, management plan and budgetary plan as shown in Figure 7.11.

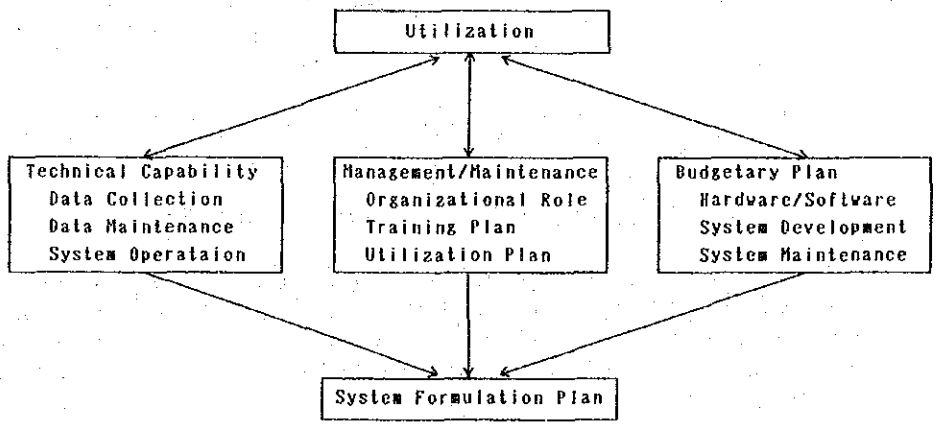


Figure 7.11 System Formulation Procedures

Technical conditions include technical capability of data collection and maintenance, operation ability on computer, and practical utilization of information from the database in traffic engineering works. Management and maintenance affairs for the system formulation should define the organizational role of data collection and maintenance, and to describe the training system for effective maintenance and utilization of the database. Budgetary considerations are on budget plan to achieve the introduction of hardware/software, system development, and data maintenance and system management.

After satisfying the above conditions on technical, management and budgetary matters, the database system will then be able to provide useful information to users depending on the better maintenance and management circumstances. Otherwise, the system will lose reliability and will become useless. That is, computerized information system should be formulated within the actual possible states of affairs as above mentioned.

(2) Principles for System Formulation

It is assumed that the fully computer aided system will change tasks and assist traffic engineering works in DOH. However, it will be necessary to estimate the amount of time and costs in system development and maintenance.

In this study, in order to achieve improved traffic operation using the new database system as soon as possible, a formulation plan to develop the system and to establish database in five years,will be proposed as a practical solution. For this reason, following conditions and assumptions are set down as a result of the former sections 7.2 and 7.3 and discussion with DOH counterparts on the road inventory system. Conditions for formulation of the system are capable of;

A. Developing and maintaining the system by means of current hardware and software owned in DOH.

B. Collecting and updating data within the current capacity of DOH.

C. Operating and managing by TED members.

D. Objective data for the database covers the whole road system under the jurisdiction of DOH, except rural and municipal roads.

7.4.2 System Function and Development

(1) Function of Road Inventory System

For practical purposes concerning traffic engineering, the inventory system should be designed in the interactive mode so that DOH engineers can operate the system by answering query statements shown on the computer display in daily use. It seems that the fourth generation language LINC, which is associated software to access the database created by DMS II in the B-A3K system, has enough capability to handle the road inventory system. System flow is presented in Figure 7.9 and operation flow in Figure 7.10.

For the above reasons, it is necessary that the road inventory system provides the following functions on input, error check and output.

a) Function for Inputting

A. Append new data records for new control section.

B. Alter data in old data records which are already stored in a database,

C. Delete a stored data record from a database.

b) Function for Error Checking

A. Check key that identifiers are not duplicated and any deficiency.

B. Check that code items correspond with the correct code.

C. Check numerical value by means of the logical relationship with a set of values in the database.

c) Function for Outputting

A. Retrieve the information for frequent daily use.

B. Arrange data records in appropriate order.

C. Select the standard output forms for road inventory.

(2) System Gradation

In the road inventory system, a database for the control section is a main feature. However, for some data items like traffic sign and traffic volume, more detailed information which can not be stored in a single database file in terms of effective computer usage, are often required to attain adequate traffic operation. Therefore, besides a database for control section, nine databases will be essential to store detailed information as shown in Figure 7.12.

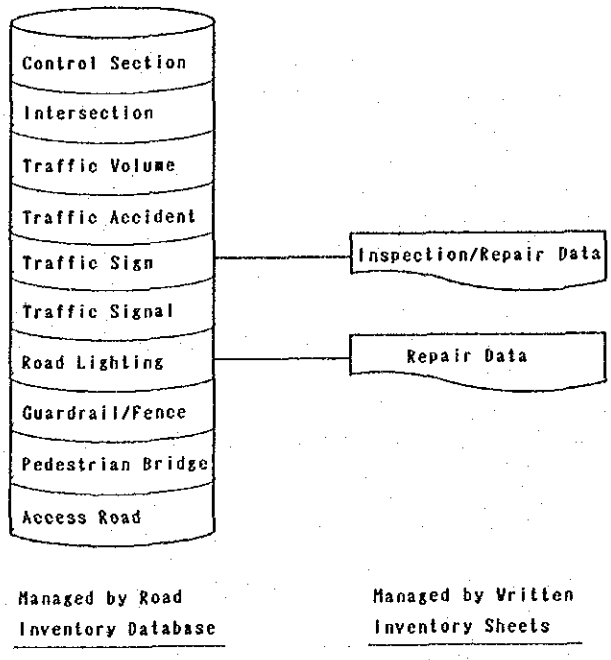


Figure 7.12 Gradation of Road Inventory System

Meanwhile, considering the DOH's current feasibility of systemization, it is necessary to manage the main traffic facilities, such as traffic sign and road lighting, by means of written inventory sheets in a form of table to supplement management works until completion of the fully computerized inventory system.

(3) Relation to Existing Road Database

Existing road databases, which are maintained by Planning Division, are being used throughout the whole DOH organization. Therefore, all items which are related to both the existing road database and inventory database, should be managed such that no inconsistencies occur between them. At present, due to the delay in establishment of the road database, database files for control link, accident and intersection are to be considered in terms of inconsistencies of data items. Details of these database files are presented in Appendix 7.13, 7.14 and Appendix 7.16.

(4) System Development Procedures

The road inventory database will be established in accordance with the system development procedure shown in Figure 7.13. The following are brief explanation of work items to be done in the course of development.

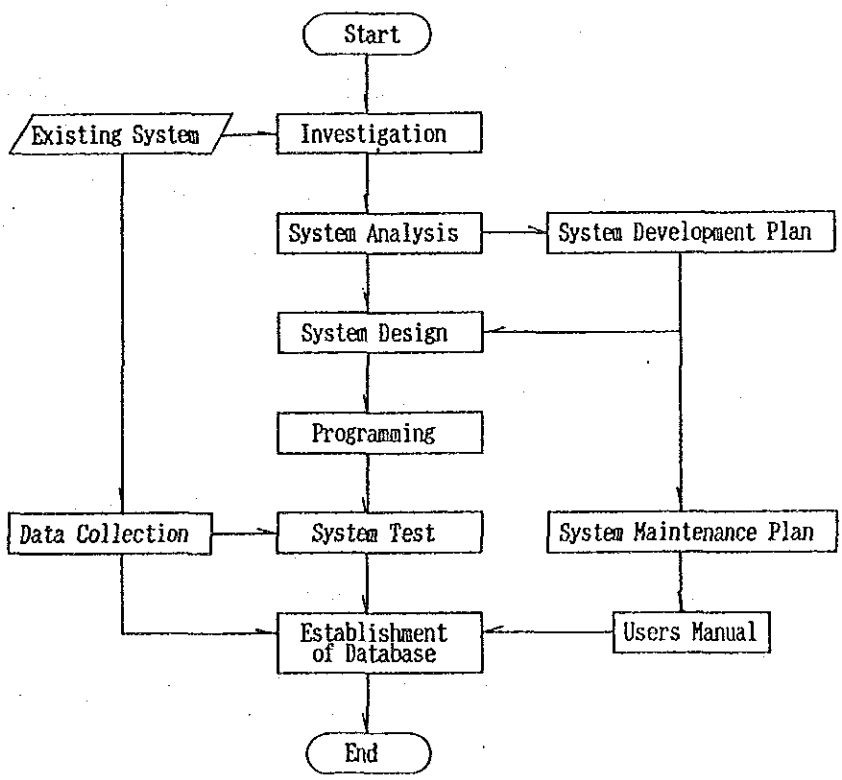


Figure 7.13 System Development Flow

1) Investigation

- To investigate the existing road database and available data in DOH, and clarify TED's requirements for the system.

- To confirm the necessary information which will be employed in the traffic engineering.

2) System analysis

- To determine the items and structures of data to be included in the database.

- To review and establish control section system for subdividing the road network.

3) System development plan

- To determine the system function and utilization plan for traffic engineering works on roads.

- To determine the budgetary plan for system development, hardware introduction, data collection and maintenance works.

- To determine the scheduling of system development and initial data collection works.

4) System design

- To adjust and confirm items between new and the existing database.

- To determine a system flow, and the scope and function of various interface systems as well as connecting system between new and the existing database.

- To design the process of input, output, database files and codes in detail.

5) Programming

To prepare the program and to confirm its operation in accordance with its design.

6) System maintenance plan

To determine the procedures of data maintenance works and the maintenance rules for updating database through the DOH organization.

7) Data collection

To collect data in detail on the whole national highway through the district offices.

8) System test

To verify the system function and operation as per design.

9) Users manual

- To prepare a manual for users describing with the aid of illustrations handling methods on updating, retrieval, printing out, code tables and measures for error messages.

- To prepare a manual describing the system and the specification on management of the database.

10) Establishment of database

To check the collected data and to establish the database, and confirm the system functions.

Table 7.6 Tentative Plan for System Development

Year / Work Item	TOPR Study	1 (First Year)	2 (Second Year)	Remarks
Investigation	----------			Completed
System Analysis	----------			Completed
System Development Plan	------	———		
System Design	------	———		by B-A3K System
Programming		———	———	by B-A3K System
System Maintenance Plan	--	———		
Data Collection	--	———	——— ———	by District Office
System Test			———	
Users Manual			———	
Establishment of Database			———	Input and Check

7.4.3 Database

(1) Identification of Road Segments

Control section should be, in principle, subdivided by traffic characteristics on the road in view of traffic engineering use. In order to subdivide which also corresponds with the existing control section system, for instance, additional three digits will be used for dividing the current control section into two or more

control sections as necessary as shown in Figure 7.14. While, the last digit is left in zero for margin of road extension in the future.

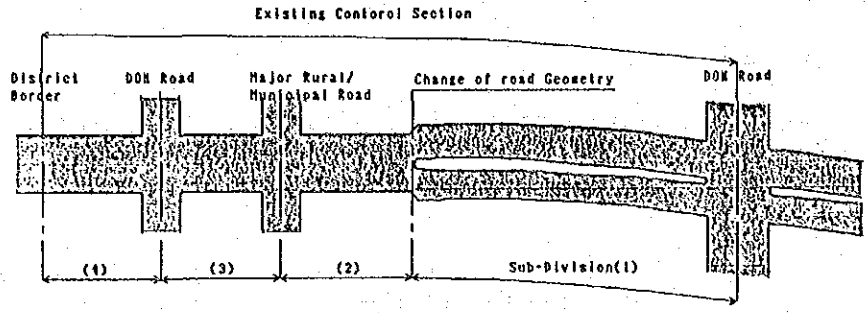


Figure 7.14 Illustration of Revised Control Section

(2) Data Items and Database

Database for the road inventory, which are stored in the main frame computer, are described in Table 7.7. Total data volume is estimated at 10.2 MB after collecting data for the whole national highway system in Thailand. The main frame computer of model B-A3K has a capacity sufficient enough to accommodate all data for the road inventory database without hindrances in load of the other system to the computer. The definition of data-base for road inventory are presented in detail in Appendix 7.13 to Appendix 7.22.

Table 7.7 Database for Road Inventory System

Name of Database	No. of Items	Record Length (Bytes)	No. of Records	Data Volume (KB)	Remarks
Control Section	62	236	11,000	2,600	to be added data on major rural/municipal roads in the future.
Intersection	39	110	9,600	1,100	ditto.
Traffic Volume	31	138	3,000	400	ditto. (/year)
Traffic Accident	29	72	3,000	200	(/year)
Traffic Sign	47	150	22,000	3,300	
Traffic Signal	18	60	5,500	300	
Road Lighting	21	74	5,500	400	
Guardrail/Fence	23	211	5,500	1,200	
Pedestrian Bridge	22	116	2,200	300	
Access Road	16	71	5,500	400	
Total	308	———	———	10.2 MB	———

Note; Number of records is based on the assumtion considering in the current data condition and identification method.

7.4.4 Data Collection and Maintenance

(1) Data Collection

It seems that available data for the database establishment is not adequate enough to cope with the new demands for traffic engineering, although current available data are not yet known.

In order to demonstrate the collection methods of inventory database, coding sheets for ten database files are presented in Appendix 7.13 to Appendix 7.22 showing the easiest way to initially collects data to field engineers.

(2) Operation Works

It is desirable that all engineers in DOH can operate the inventory system by themselves, although due to the shortage of system engineers and operators, only a designated section should conduct the task of updating and revision of data periodically for the sake of the better management of the database.

(3) Maintenance and Management

Updating of old data should be both systematically and periodically implemented to ensure the effective utilization of the database to users. Data maintenance works are necessary for the following items;

1) Maintenance for alteration of road network

To add new control sections, to split and/or combine the existing control sections to be modified.

2) Data collection, checking and inputting

To collect, check and input data due to the new installation and repair works in addition to the alteration of the road network.

Comprehensive maintenance procedures are shown in Figure 7.15. This figure shows that it is essential to establish an organizational role for the center office and for the district offices throughout the DOH.

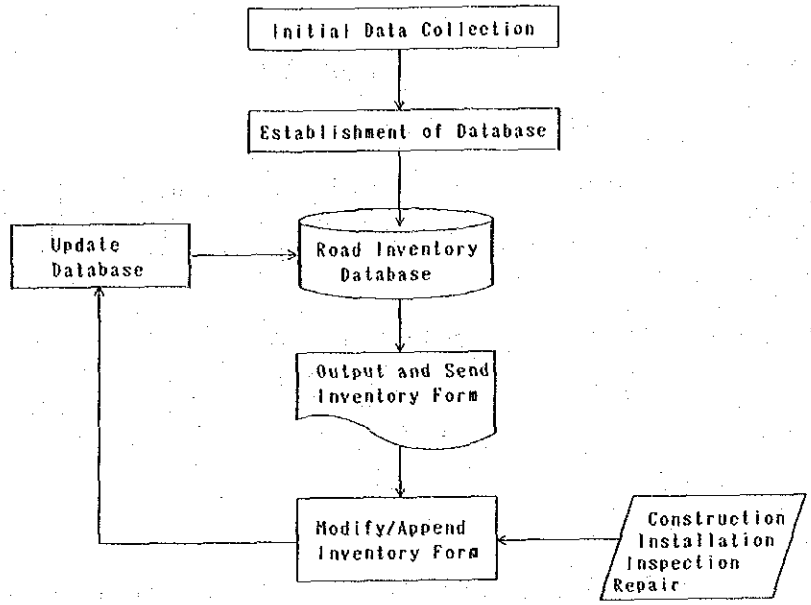


Figure 7.15 Data Maintenance Flow

7.4.5 Utilization of Inventory Database

(1) Circulation of Utilization and Maintenance

Important tasks which make full use of the computerized information system is for system maintenance to provide effective utilization, in addition to the technical affairs for the system. Conversely, the better and frequent utilization of the system causes the higher level of maintenance of the database depending on the higher user's interest in the system. The above relations can be shown in Figure 7.16. New data, which are to be updated into the database, generates in construction, inspection and repair works for roads and it's facilities. Meanwhile, road inventory database is wide use of all the above works for roads and facilities in such a way that the database supplies information essential to planning and management.

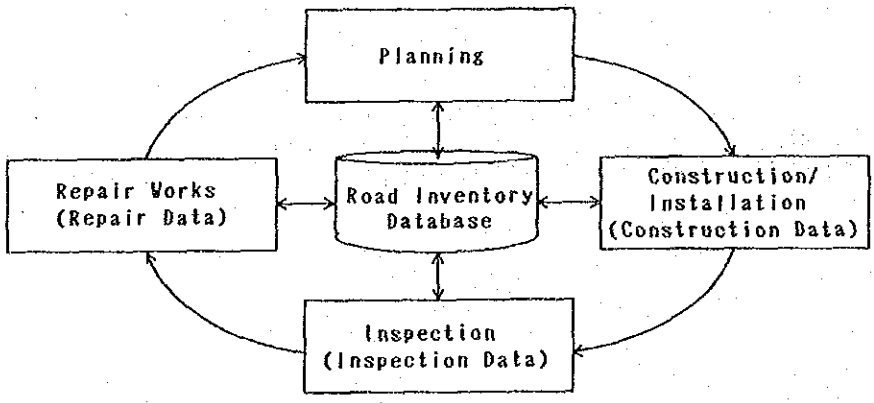


Figure 7.16 Circulative Relation between Road Works and Database

(2) Utilization of Database

The well maintained road inventory database enables the road administrators to readily access their road conditions on road geometry, traffic facilities, traffic volume and traffic accident. Beside grasp of the current road conditions, road inventory database will assist the traffic engineering works within jurisdiction of TED by means of providing comprehensive and detailed data as follows;

1) For traffic operation works

A. To identify hazardous road section.

B. To provide road condition data for traffic census.

C. To provide road condition data for O-D survey.

2) For planning works

A. To provide road geometry data for road improvement.

B. To provide traffic facility data for newly installation/rearrangement plan.

C. Budget plan.

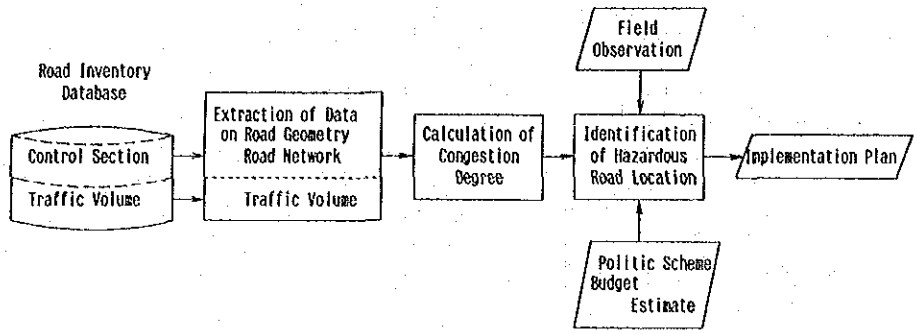
3) For management works

A. Work plan on inspection and repair for traffic facilities.

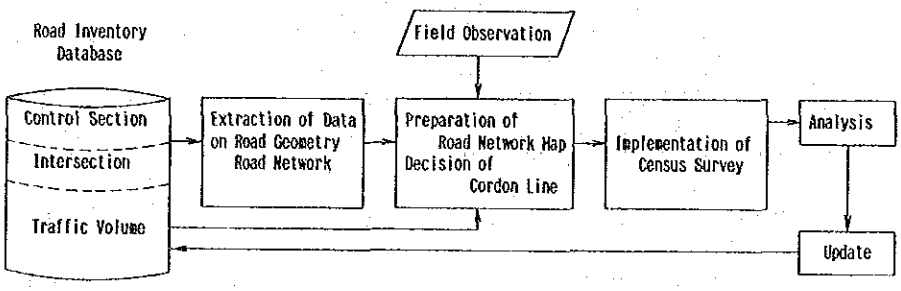
B. To provide traffic facility data for management.

C. To provide data for administration of access road.

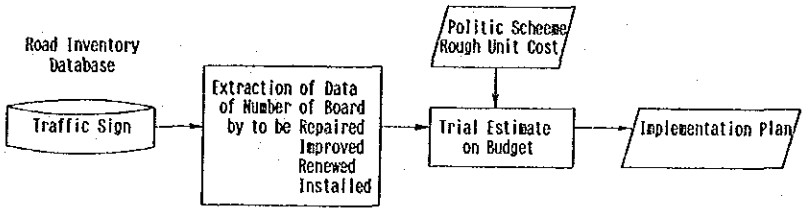
Three examples are presented on practical application procedures for traffic engineering works as shown in Figure 7.17. They are identification procedure of hazardous road section, census plan and update of analyzed traffic data, and procedure for traffic sign management plan.



Example-1



Example-2



Example-3

Figure 7.17 Illustration of Utilization of Inventory Database

CHAPTER 8 TECHNICAL GUIDELINES AND ENGINEERING SPECIFICATIONS ON TRAFFIC SAFETY AND TRAFFIC CONTROL DEVICES

CHAPTER 8 TECHNICAL GUIDELINES AND ENGINEERING SPECIFICATIONS ON TRAFFIC SAFETY AND TRAFFIC CONTROL DEVICES

8.1 INTRODUCTION

8.1.1 Concept of Technical Guidelines and Engineering Specifications

Efficient and economical road construction, improvement and maintenance are attained by methods including applying reasonable technical standards developed based on well conceived techniques and ample experiences gained through actual road management and traffic operation. This has led to establishment of many technical standards on various aspects of highway engineering, based on research and studies carried out over many years. In contrast, in a number of developing countries, there appears to be no authorized standards of the highway and the traffic engineering; thus, road planning and designing as well as the traffic operation are done by the methods and technical criteria selected by individual engineers on a project by project basis.

Although DOH has accumulated knowledge and information on highway and traffic engineering, it is yet to develop a body of comprehensive technical standards applicable to all aspects of the highway planning and designing, as well as the traffic operation. With the primary objective of applying them to case studies of planning for the traffic operation, some essential technical standards are proposed.

Any technical standard should be determined taking into account many matters such as the results of technical experience and research, the social environment, economic viability and characteristics of drivers in the relevant country. As such the technical standards to be proposed by the Study which has been performed under a number of constraints including limited time and information, could be safely called "technical guidelines and engineering specifications". We do not rule out the possibility that DOH will make the proposed guidelines and specifications its technical standards, however, if they are found reasonable.

8.1 2 Collection and Review of Relevant Reference Materials in Thailand

(1) *Collection and Review of Relevant Reference Materials*

The technical guidelines and engineering specifications should maintain consistency with prevailing engineering practices in Thailand. Relevant references were col-

lected not only from DOH, but also from other concerned agencies including the Ministry of Industry and private companies who supply apparatuses and materials to DOH.

Any technical guideline or engineering specification in any country should be worked out using the knowledge accumulated through studies, research and actual experience in the country. However, practices in highway and traffic engineering projects in Thailand have been based on the standards used in other countries such as U.S.A., U.K. and Japan.

(2) Review of Technical Guidelines Proposed in the Phase I Study

Technical guidelines for the following traffic safety devices were proposed in the course of the Phase I Study based mainly on technical standard utilized in Japan;

- Traffic signal
- Guard fence
- Street lighting
- Delineator
- Sidewalk and bicycle path
- Crossing facility for pedestrian

In addition, existing technical guidelines on traffic signs and pavement markings were also reviewed. These proposed guidelines have been effectively utilized by DOH for the implementation of traffic safety improvements. However, DOH made several comments on these technical guidelines, based on actual practices for the installation of safety devices.

Therefore, the technical guidelines on traffic safety devices proposed under the Phase I Study have been generally reviewed on the basis of comments from DOH, and revised technical guidelines of traffic safety devices are also presented in this report, together with newly prepared technical guidelines and engineering specifications.

8.1.3 Traffic Operational Measures

In general, the traffic operation can be promoted from the highway and traffic engineering point of view, through the improvement of the traffic environment based on the following principles.

A. To separate the conflicting traffics by time and/or by space.

B. To simplify the traffic flows.

C. To create the proper driving circumstances.

To accomplish traffic operational improvement based on these principles, two engineering approaches should be harmonized appropriately; one is the installation of road appurtenances for traffic control, and the other is the improvement of road itself. Table 8.1 is the list of typical measures for traffic operational improvement classified in compliance with the above mentioned two approaches. These measures should be selected and applied with a due consideration.

Table 8.1 Traffic Operational Improvement Measures

Principle of Operational Improvement	Traffic Operational Improvement Measures	
	Installation of Road Appurtenances	Improvement of Road
To separate the conflicting traffics by time and/or by space	- Traffic Signal - Stop Control (Sign, Marking) - Guard Fence - Longitudinal Pavement Marking - Raised Pavement Markers - Crosswalk	- Construction of By-pass and Expressway - Sidewalk - Bicycle Path - Bicycle-Pedestrian Path - Pedestrian Overpass - Median - Frontage Road - Refuge Island - Motorcycle Lane - Climbing Lane - Passing Lane
To simplify the traffic flows	- Channelization of Intersection - Pavement Markings - Guide Signs - Access Control - One-Way System - Parking Restriction	- Bus Bay - Grade Separation - Traffic Island
To create proper driving circumstances	- Street Lighting - Post Delineator - Curve Mirror - Warning Signs - Guide Signs - Glare Screen - Traffic Information System	- Elongation of Sight Distance - Improvement of Shoulders - Road Geometry Improvement (Alignment, Cross Section) - Anti-Skid Treatment - Pavement Leveling
To mitigate the accident severity	- Guard Fence - Speed Control - Overtaking Control - Breakaway Treatment of Roadside Appurtenance	- Pavement Grooving - Side Slope Flattening

Note : 1. Measures listed in the table are not all-inclusive.
2. Classification was made according to the principal facet of each measure.

These measures prove to be very effective in traffic operational improvement particularly when they are appropriately planned and accompanied by adequate educational programs and the strict enforcement of laws and regulations to the road users. On the other hand, improper installation of them are not only ineffective but sometimes even causes traffic congestion and danger because they may induce uneasiness to road users. Therefore, it is very important to prepare the guidelines and specifications on the traffic operational improvement (they are referred to as traffic safety and traffic control devices for practical purpose hereinafter). Traffic safety and traffic control devices in the Study include not only the road appurtenances but the portion of road structure such as sidewalk.

In the Study, technical guidelines and engineering specifications on the following traffic safety and traffic control devices have been prepared and they are presented in the separate volume of this report "Technical Guidelines and Engineering Specifications". While, summaries of these technical guidelines and engineering specifications are presented in this "Main Volume".

1) Median Divider, Facilities for Channelization and Added Lane in the Neighborhood of an Intersection

2) Climbing Lane, Passing Lane and Motorcycle Lane

3) Traffic Signal

4) Traffic Sign

5) Pavement Markings

6) Crossing Facility for Pedestrians

7) Sidewalk and Bicycle Path

8) Street Lighting

9) Delineator

10) Guard Fence

11) Pavement Treatment

12) Other Facilities

8.2 SUMMARY OF TECHNICAL GUIDELINES AND ENGINEERING SPECIFICATIONS

8.2.1 Median Divider, Facilities for Channelization and Added Lane in the Neighborhood of an Intersection

(1) Technical Guidelines

a) Median Divider

A. The median is a highly desirable element on all major roads with four or more lanes.

B. The width of median should be more than the value shown in Table 8.2. However, in unfavorable locations, such as bridges, viaducts (including flyovers) and underpasses, the widths may be reduced to the values in parentheses.

Table 8.2 Width of Median

Unit : m

median	1.50 (1.00)** *(minimum)*
marginal strip	0.30 (0.25)**
c*	0.50 (0.25)**
lateral clearance	0.80 (0.50)**
appurtenances of road	0.50 (minimum)

Note * : see Figure 1.1 in the "Technical Guidelines and Engineering Specifications"
** : Width in parentheses are applied in the case of bridges, etc.

C. The width of the marginal strip should be 0.30m. In an unfavorable place, such as bridge and viaduct, the width may be reduced to 0.25m.

b) Facilities for Channelization

1) Channel

A. When designing a channel, the speed of the design vehicle and various other conditions must be taken into account.

B. For the arrangement of a channel, the traffic volume, method of traffic control, and pedestrian movements should be taken into account, in order to prevent disturbance on traffic flow.

C. The standard width of a channel corresponding to the design vehicles is shown in Table 8.3.

Table 8.3 Width of Channel

Unit : m

Design Vehicle / Outer Radius of Channel	Semi-Trailer (Major Trunk Roads)	Ordinary Motor Vehicle (Other Roads)
13 ≤ R < 14	8.5	5.5
14 ≤ R < 15	8.0	
15 ≤ R < 16	7.5	5.0
16 ≤ R < 17	7.0	
17 ≤ R < 19	6.5	
19 ≤ R < 21	6.0	4.5
21 ≤ R < 25	5.5	
25 ≤ R < 30	5.0	4.0
30 ≤ R < 40	4.5	
40 ≤ R < 60	4.0	3.5
60 ≤ R	3.5	

D. The width of channel should be determined according to the design vehicle, the radius of curvature, and the turning angle. The width should not be too wide or too narrow.

2) Traffic island and separator

A. A traffic island and a separator should be provided to maintain proper and safe traffic flows at an intersection, where channelization is considered.

B. In principle, a traffic island and a separator should be provided with curbs.

C. In the following cases, it is desirable to provide a separator at the approach of an intersection, even though a two-way highway is not separated by a median.

- Where roads with a design speed of 60 km/hr, or higher, intersect each other.

- Where many pedestrians cross a carriageway and the crossing distance is long.

D. For the design, the channel should be located first and then traffic islands and separators would be positioned within the remaining portion. For this case, an appropriate nose offset and set-back should be provided.

E. The appropriate width, length, and area of traffic

islands or separators should be determined taking their function into full consideration.

F. As a general rule, an alignment will be the combination of a straight line and a circular curve.

G. It is desirable to provide indications with pavement markings, etc. on the approach to a traffic island or a separator.

c) Added Lane in the Neighborhood of an Intersection

1) Right turn lane

A. At an at-grade intersection, a right turn lane should be provided except in the following cases.

- Right turn prohibition.
- On Minor Roads and Access Roads, when they could be considered to have sufficient capacity in a peak hour.
- On a two-lane road with a design speed of 40 km/hr or less, when the design traffic volume is less than 200 vehicles/hour and the right turning rate is less than 20%.

B. The length of the right turn lane should be determined according to the design speed and the number of vehicles stored in the right turn lane.

2) Left turn lane

A. In the following cases, a left turn lane or left turn roadway should be provided.

- Where an intersecting angle is not more than 60 degree and the left turn traffic volume is heavy.
- Where the left turn traffic volume is very heavy.
- Where the speed of left turning vehicles is high.
- Where the left turn traffic volume is heavy and there are many pedestrians crossing the carriageway at the left turning exit.
- For special cases when provision of a left turn lane is warranted.

B. The length of the left turn lane should be determined according to the design speed and the number of storage vehicles.

3) Speed change lane

A. In the following cases, a deceleration lane should be provided.

- Where there are decelerating or diverging traffic from the Major Trunk Roads with full or partial access control.

- Where the necessity is warranted.

B. In the following cases, an acceleration lane should be provided.

- Where there are accelerating and merging traffic into the Major Trunk Roads with full or partial access control.

- Where the necessity is warranted.

C. The lengths of the speed change lane vary according to the characteristics of roads, the difference between design speed of the through lane and that of the speed change lane, the method of traffic control, etc.

4) Cross section in the neighborhood of an intersection

A. When the turning lane or the speed change lane is provided at an intersection, the width of a lane other than the turning or the speed change lane may be reduced to 3.0m on Major Trunk Roads and Major Roads in urban areas. On other roads, the width may be reduced to 2.75m.

B. The standard width of the turning lane and the speed change lane is 3.0m.

C. When the turning lane or the speed change lane is provided at an intersection, an appropriate transition run-off should be provided, in conforming to the design speed.

D. The value of lane widths should be as shown in Table 8.4, conforming to the classification of road.

Table 8.4 Lane Width at an At-grade Intersection

Unit : m

Type (Area)	Road Class	Lane width of Mid-block Section	Width of Through Lane in the Section Provided Added Lane	Width of Added Lane
Urban	1. Major Trunk Roads	3.5	3.5 or 3.25	3.25, 3.0 or 2.75 (2.5)**
	2. Major Roads	3.25 [3.5]*	3.25 or 3.0	
	3. Minor Roads	3.0	3.0 or 2.75	
Sub-urban	1. Major Trunk Roads	3.5	3.5	
Rural	2. Major Roads	3.25 [3.5]*	3.25 [3.5]*	
	3. Minor Roads	3.0	3.0	
	4. Access Roads	3.0	2.75	

Note -- * : Lane width in [ ] will only be applied when necessary.
** : In an unavoidable case, width shown in ( ) can be applied for a right turn lane in urban area.

8.2.2 Climbing Lane, Passing Lane and Motorcycle Lane

(1) Technical Guideline

a) Climbing Lane

A. The provision of a climbing lane is desirable, if necessary, for a road section with upgrades exceeding 5% (or 3% in the case of an express highway or a highway with a design speed of more than 100 km/hr).

B. Decision as to where a climbing lane is required can be considered in conjunction with the reduction of running speed of heavy vehicles by up-grade and the traffic capacity.

C. It is desirable the lane width of a climbing lane to be 3.0m.

b) Passing Lane

A. The provision of a passing lane is desirable, if necessary, for a two lane road, where passing of a slow moving vehicle is difficult over a long distance.

B. For the selection of a location to provide a passing lane, the following points should be taken into account.

- To secure sufficient sight distance at both diverging and merging points.
- To consider the relation with access roads, intersections and roadside condition.

C. Either an overtaking lane method or a slower traffic lane method should be selected which will take into due consideration the road condition, traffic characteristics, etc.

D. It is desirable to provide a passing lane within each 5 to 7 km along a two lane road.

E. The lane width of a passing lane should principally be the same as the lane width of the main carriageway.

F. It is desirable the standard length of a passing lane (excluding taper length) to be 800m for an overtaking lane method and 500m for a slower traffic lane method. This length can be reduced to 500m and 300m respectively, if circumstances are unavoidable.

c) Motorcycle Lane

Provision of a motorcycle lane is desirable at a road section with one of the following traffic conditions.

A. Average traffic volume, excluding motorcycle, is more than 2,000 per day and motorcycle traffic volume is more than 1,000 per day.

B. Average traffic volume, excluding motorcycle, is more than 2,000 per day and motorcycle traffic volume is more than 500 per day, where the running speeds of vehicles are considerably high.

8.2.3 Traffic Signal

(1) Technical Guideline

a) Summary of Warrants

A. Pretimed signal

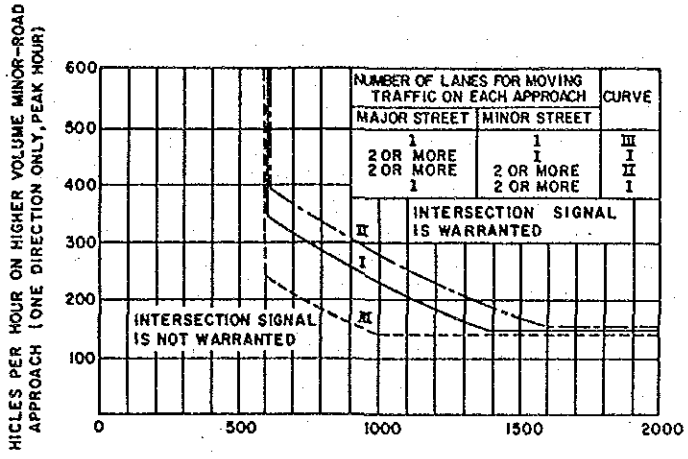


Figure 8.1 Warrant for Traffic Control by Pretimed Signal

B. Semi-traffic-actuated signal

Table 8.5 Warrant for Traffic Control by Semi-Traffic-Actuated Signal

	Vehicle per hour on major road (total of both approaches)	Vehicle per hour on higher-volume minor road approach (one direction only)
Peak hour traffic volume	900 or more	100 or more

C. Pedestrian signal

Table 8.6 Warrant for Traffic Control by Pedestrian Signal

	Vehicle per hour on the street (total of both directions)	Pedestrian per hour on the crosswalk crossing the road
Peak hour traffic volume	650 or more	200 or more

D. Traffic accident prevention

Table 8.7 Warrant for Traffic Accident Prevention by Traffic Signal

	Accidents Preventable by Traffic Signals
Number of Accidents within a 12-month Period	5 or more

(2) Engineering Specification

a) Method to Determine the Signal Phase and Timing

A. Basic planning procedure is uniform for any cases as illustrated in Figure 8.2.

B. Based on the compiled traffic volume data, it is necessary to quantify the traffic volume of in the morning and evening peak hours. These 1 hour traffic volume is considered to be the design traffic volume.

C. The design of the signal phase should be carried out by the following procedures with due consideration for the shape of an intersection, the traffic conditions and the location of an intersection.

- Draw the traffic stream lines for all approaches.
- Combine traffic stream lines which could operate together without conflict. Each combination of traffic streams may be considered to be a separate signal phase.
- Recombine signal phases in due consideration of traffic conditions, if possible, and further combine of traffic stream lines for each signal phase.
- Determine the sequence of the signal phases.
- Amend the signal phasing, if necessary, based on design judgement.

D. The saturation flow rate (optimum saturation flow rate) can be calculated using the standard value of the saturation flow rate at an signalized intersection and several correction factors applicable to road/traffic conditions at the site.

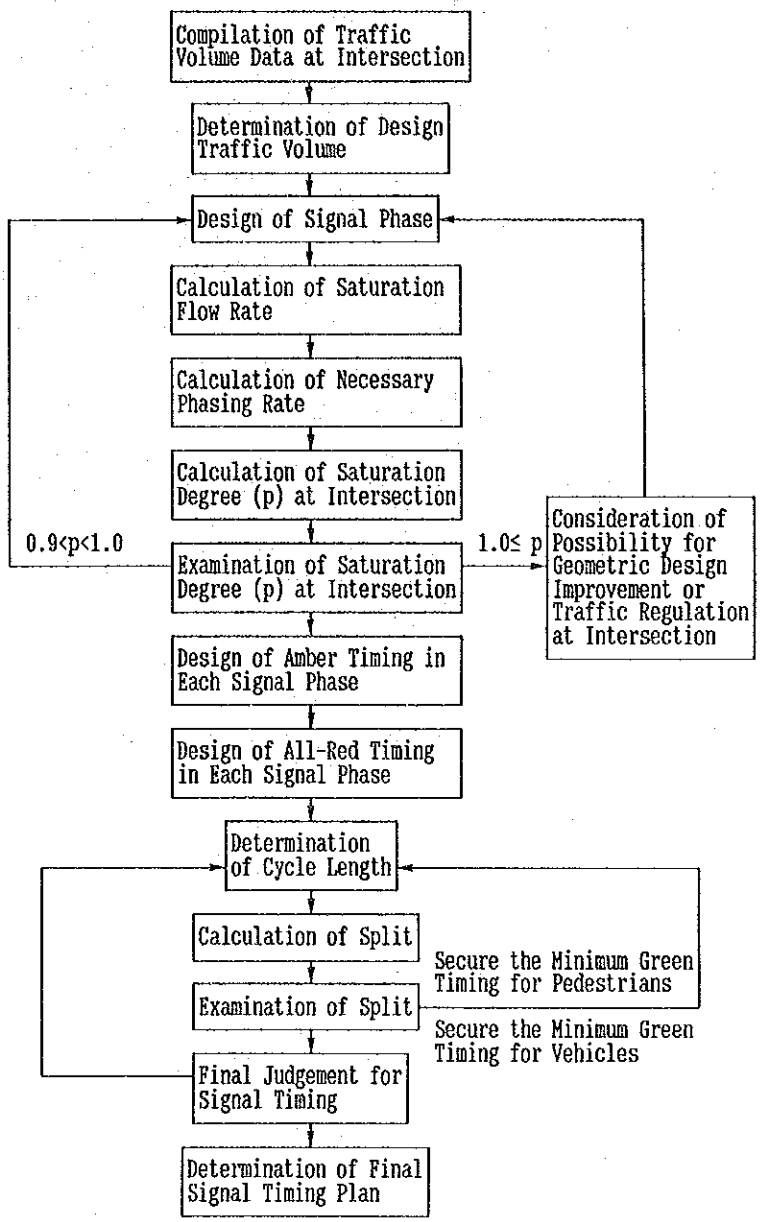


Figure 8.2 Procedure of Signal Phase and Timing Design

E. After calculation of the saturation flow rate of each approach leg, it is necessary to calculate whether the determined signal phase can accommodate the design traffic volume, by using the saturation degree.

F. In order to avoid conflicts between vehicles in an intersection during the transition period of signal phases, it is necessary to ensure that vehicles clear the intersection. The time to clear vehicles is called the clearance time and it is indicated either by an amber phase or an all-red phase.

G. When the phasing method is determined and the saturation flow rate at an intersection is obtained, it is possible to determined the desirable cycle length for the phase and calculate the split.

b) Concept for Coordinated Signal Control

A. For designing the coordinated signal control, it is necessary to examine the various factors related to the signal control for the whole link of the coordinated system.

B. The cycle length suitable for an intersection with the highest saturation degree in a coordinated control system is generally employed as the common cycle length.

C. The split of a coordinated system is determined for each intersection.

D. The offset is a specific parameter of signal control for the coordinated system and it greatly affects the efficiency of the system.

c) Design of Traffic Signal Control

1) Fixed pattern control

For the design of a fixed pattern control system, it is necessary to identify the 3 patterns of traffic condition by day, to determine suitable control parameters (cycle length and split) applied for each pattern and to determine the time range for each control pattern.

2) Vehicle actuated control

For the design of a vehicle actuated control, it is necessary to calculate the minimum green timing and the extended green timing. In addition, in order to maintain the appropriate split, it is necessary to set an extension limit to the phase.

3) Bus priority control

For a bus priority control, either the green timing extension control or the red timing reduction control should be employed.

4) Train actuated control

For a train actuated control, the signal phase should

be activated before functioning of railway crossing facilities. At the same time, the minimum required green timing as well as the clearance time for an intersection should be set in the preceding green phase.

5) Multi pattern coordinated signal control system

The multi pattern coordinated signal control is a kind of coordinated control system with provision of suitable control parameters for prefixed time ranges for the normal working day, Saturday and Sunday.

6) Vehicle actuated coordinated signal control system

The control pattern of a vehicle actuated coordinated signal control systems differ depending on the traffic conditions. In addition, the combination of the control areas may differ under the area control system.

d) Installation of Signal Equipments

1) Basic requirement of signal installation

- It is necessary to anticipate the type and installation location of traffic signals which may be required at the completion of the construction or in the near future.

- The geometric design of signalized intersection should be done in due consideration of installation locations of signal equipments as well as the effective signal operation.

- The control method and the control constants can be determined through due considerations of installation density of signals and traffic condition. If a new signal is installed adjacent to an existing fixed control signal, it is necessary to consider the introduction of either an interconnected control system or a coordinated control system.

2) Installation of controller

After the determination of the control method, the phasing and the required number of signal displays, it is necessary to select a suitable controller. In most cases, a controller is installed as a pedestal type.

3) Installation of vehicle detector

For the signal control, a ultra-sonic vehicle detector

is mainly used due to the ease of installation and the superior maintenance requirements. The installation location of a vehicle detector is different for each control method.

e) Management of Traffic Signal Operation

A. After the installation of traffic signals, it is necessary to adjust and to modify control constants, in order to cope with unexpected traffic conditions.

B. After the installation of a traffic signal, it is necessary to monitor the possibility of a drastic change in traffic conditions, any unexpected type of traffic accident, and undesirable traffic conditions. It is then necessary to modify the signal phasing to cope with these situations, if so required. The modification of the signal phasing should be carried out based on the design method of the signal phasing.

C. It is necessary to up-grade the control method, if changing the control constant and phasing method cannot achieve the desired results.

8.2.4 Traffic Sign

(1) Engineering Specification

a) Material of Traffic Sign

The materials utilized for the traffic sign board as well as the post should have sufficient strength, good durability, and easiness for maintenance. In addition, the quality of materials as well as shape of traffic signs should harmonized with surrounding atmosphere.

b) Reflective Material

The reflective materials should have sufficient retro reflection from a visibility point of view and adequate durability, and they should be easy to maintain.

c) Illumination Equipment

The illumination equipment for the traffic sign should have adequate illuminance and durability, and maintenance should be easy.

d) Structure of Traffic Sign Board

The size of the traffic sign board should follow the "The Manual of Traffic Control Devices, 1988" prepared by DOH, while the structure of sign board should be of adequate strength.

e) Post of Traffic Sign

The post of traffic sign should have adequate strength in consideration of the size of a sign board and condition of installation location.

f) Foundation and Installation

The foundation of the traffic sign should be designed in consideration of the dead load of a sign board and post as well as the wind load. Installation of a traffic sign should be carried out in safety and certainly without effects from other facilities and traffic flows.

g) Inspection and Maintenance of Traffic Signs

Routine inspection of traffic signs is necessary to maintain the function of individual traffic sign as well as the function to continuously provide necessary indications to traffic. In addition, it is desirable to carry out additional inspection after the abnormal weather condition, such as typhoon.

When any disorder is found on inspection, it is necessary to repair it immediately. In particular, if any traffic sign has an unsafe clearance, this may result in a bad accident and immediate maintenance is necessary.

h) Traffic Sign Data Book

In order to carry out rational and speedy maintenance of traffic signs, it is desirable to prepare a traffic sign data book to fill in necessary items at each traffic sign.

8.2.5 Pavement Markings

(1) Engineering Specification

a) Basic Requirement for the Material

The basic requirement for the pavement marking materials are as follows.

A. The visibility of the pavement markings should be good throughout the day, especially in rain.

B. The material should have good durability and a quick drying time. In addition, quick application should be possible.

C. The material should have sufficient skid resistance for both vehicular traffic and pedestrian traffic.

D. The cost performance of the material is required to be high. This mean that the life span of the material is sufficient to justify the application cost.

E. For the application of the pavement markings, it is necessary to select the appropriate application method according to the type of material, road and traffic conditions.

b) Classification of Materials and Application Method

1) Traffic paint

Table 8.8 Characteristics of Traffic Paint by Type

Item	Type 1 (Cold Paint)	Type 2 (Hot Paint)	Type 3 (Melt Application)
Form	Liquid	Liquid	Powdery bulk materials
Specific Gravity	1.3 to 1.6	1.4 to 1.7	1.8 to 2.3
Heating Residue	60% or over	65% or over	99% or over
Primary Coating	Not required	Not required	Required
Application Temperature	Ambient temp.	Heated to 50 to 80°C	Heated to melting temp. 180 to 220°C
Application Method	-Roller blushing -Brushing -Spraying	-Air spraying -Airless spraying	-Hand pushing screed -Self propelled machine
Skilled Level	Nothing special	Required	Required
Curing	Evaporation of solvent	Evaporation of solvent	Air cooling
Reflection at Night * - White - Yellow	 Good Good	 Excellent Excellent	 Excellent to good Good to excellent
Abrasion Resistance	Low	High	Higher
Interruption to Traffic When It IS Applied	Little	Less	Least
No Pick Up Time	Within 15 min.	Within 10 min.	Within 3 min.
Cost (Thickness)	Least expensive (0.2mm)	Less expensive (0.4mm)	Expensive (1.5mm)
Restriping Required	4 to 8 months	8 to 15 months	10 to 20 months

Note * : Reflection depends on the use and rate of glass beads.

2) Pre-fabricated Tape

Pre-fabricated tape consists of either a rubber or plastic base, coloring pigments, extender, synthetic resin varnishes and reflective materials. Application of the pre-fabricated tape is suitable in only the following cases.

- Letters and symbols over a small area.
- Temporary markings.

8.2.6 Crossing Facility for Pedestrians

(1) Crosswalk

a) Technical Guideline

1) Summary of warrant

Crosswalk may be installed where:

A. More than 100 pedestrians cross carriageway per hour.

B. A number of school children cross carriageway.

C. Designated as walking parts within an intersection.

D. Vehicular traffic makes it difficult for a number of pedestrians to cross carriageway.

b) Engineering Specification

1) Planning methods

A. Type of markings for crosswalk

There are three kinds of pavement markings for crosswalks, namely, zebra markings with white color paint, two parallel solid lines with white color paint and two parallel dotted lines with road studs. The zebra markings are superior to other types of marking in visibility of crosswalks existence.

B. Planning conditions

It is desirable to plan crosswalks in the following manners.

- The standard width of crosswalks should be 4.0m.
- Pedestrians should cross the road in one movement.
- Stop lines should be painted in association with the crosswalk markings.
- The minimum interval of crosswalks shall be 200m in urban area and 300m in the other areas with exception of the areas in the vicinity of schools, hospitals, and where pedestrian volume is heavy enough to justify installation of other crosswalks in spite of the above minimum intervals.

2) Basic concept for designing a crosswalk

Basic concepts for the design of crosswalks are as described below.

A. Location of a crosswalk should comply with the natural pedestrian flow as far as possible.

B. The installation angle of a crosswalk should be at right-angles with the carriageway.

C. Location of a crosswalk should be close to the center of an intersection.

D. Crosswalks should be installed at locations visible to drivers.

E. Length of crosswalk should be desirably less than 15m.

(2) Pedestrian Refuge Island

a) Technical Guideline

1) Summary of warrant

A. Pedestrian refuge island may be installed at the sections where pedestrians can not cross carriageway in one movement of crossing and forced to wait for a traffic gap in the middle part of carriageway with 4 or more lanes.

B. Pedestrian refuge island should, in principle, be installed in combination with a crosswalk.

b) Engineering Specification

1) Planning method

It is desirable to plan pedestrian refuge islands in the following manners.

A. The minimum width of island should be 2.0m.

B. The pedestrian refuge island should be protected from direct collisions by vehicles by means of guard fence, curbstone and the like.

C. The pedestrian refuge island should be provided with adequate devices by which the vehicle drivers ap-

proaching to or passing by the refuge island, could be warned of the existence of the refuge island.

(3) Pedestrian Overpass

a) Technical Guideline

1) Summary of Warrant

Pedestrian overpass, at mid-block section or at non-signalized intersection, is warranted under the following conditions.

A. The number of crossing pedestrians per hour exceeds 100 persons at a peak hour, and the condition of traffic volume and the crossing distance meet the range indicated by the oblique line in Figure 8.3. For the crossing of school children, Figure 8.4 should be used.

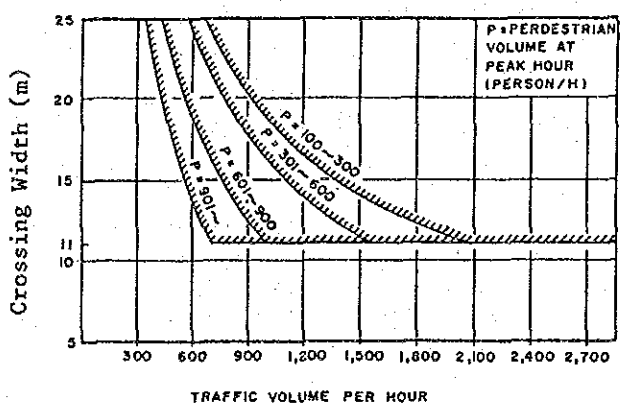


Figure 8.3 Warrant of Pedestrian Overpass

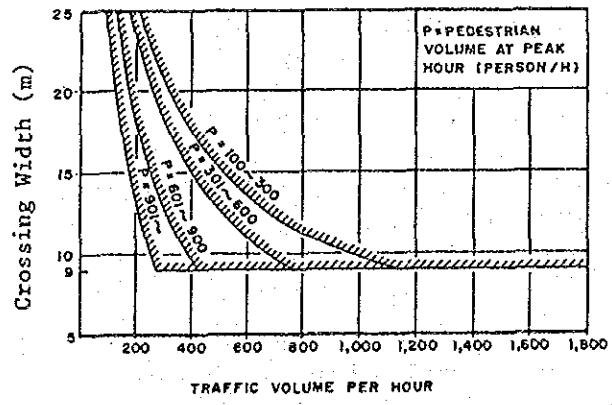


Figure 8.4 Warrant of Pedestrian Overpass for School Children

B. The following conditions are met.

- The crossing distance exceeds 25m, and there are no proper space to construct median or refuge island where pedestrians can wait for traffic gap.
- Pedestrian volume is so heavy that vehicular traffic is affected to a large extent.
- No pedestrian is allowed to cross to ensure high running speed of vehicles on roads such as expressways.
- When pedestrian volume is heavy at such as locations, within 200m from railway crossing, immediate vicinity of grade separated road, or substandard sight distance, where pedestrian safety cannot be secured by at-grade crossing.

b) Engineering Specification

1) Standard for pedestrian overpass design

A. Width of footpath, step and ramp

- The minimum width of footpath of pedestrian overpass should be 1.5m; however 2.0m when bicycles, baby carriages and wheelchairs are expected to use the overpass, as shown in Table 8.9.
- The width of step and ramp should be at least 1.5m and 2.0m, respectively, and a minimum of 1.2m and 1.7m, respectively under very special conditions (see Table 8.9). As for the step with ramp, the minimum width of a portion of ramp should be 0.6m as a standard.

Table 8.9 Minimum Width of Pedestrian Overpass

Unit : m

Method of Access	Minimum Width of Footpath	Minimum Width of Step or Ramp	
		Standard	Reduction
Step	1.5	1.5	1.2
Ramp	2.0	2.0	1.7
Step with Ramp	2.0	2.1	1.8

B. Type of pedestrian overpass

The type of the pedestrian overpass should be determined with due consideration, such as minimization of climbing height and harmony with adjacent environment.

C. Pier

The location and the structure of piers should be determined from an the examination of the sight distance of vehicular traffic, etc. For a pier susceptible to vehicle collision,it is necessary to install a rigid guard fence, such as a concrete wall.

D. Foundation

The foundation of a pedestrian overpass should be an appropriate structure in consideration of the scale of the superstructure, type of a overpass, the ground conditions, the location, structure and implementation method of the underground utilities.

E. Overpass access type

- The most suitable means of access to a pedestrian over-pass should be selected.
- If only pedestrians are supposed to use a pedestrian overpass, these means should be steps in principle.
- If the passage of bicycles, baby carriages and wheelchairs are considered, it is necessary to provide a ramp. However, if it is difficult to provide a ramp due to the site condition or for a special reason, steps with a ramp should be provided.
- The standard gradient of steps should be 50%. On the other hand, the gradient of a ramp and steps with a slope should not be more than 12% and 25%, respectively.
- Where the vertical climbing height exceeds 3m by steps, it is necessary to provide a landing.

F. Handrail

- It is necessary to install handrails along steps, a landing and a ramp. For steps with more than 15cm in height or less than 30cm in stepping width and where the width is more than 3m, it is desirable to install a handrail in the center.

- In an area with many handicapped users, it is desirable to also install handrails other than steps and some special indications for blind users.

G. Lighting

In principle, it is necessary to install lighting at a pedestrian overpass. However, where night time use is expected to be very limited, installation of lighting may be excluded.

- Illumination : Fluorescent lamp or mercury vapor fluorescent lamp.
- Illuminance : More than 20 lx.
- Lighting equipments should be designed so as not to adversely affect vehicle drivers.

H. Vibration

The vibration of the main girder caused by the live load should not cause an unpleasant experience for pedestrians.

I. Color

The color of a pedestrian overpass should be selected with due consideration for the harmony with the adjacent environment. In addition, where a pedestrian overpass installed near a signalized intersection, it is desirable not to use color similar to the signal displays.

2) Maintenance of pedestrian overpass

A. In order to maintain a clean condition of the surface, the girder, handrails and etc., it is necessary to carry out the regular cleaning of a pedestrian overpass.

B. The routine inspection should be done in order to check the condition of the girder, painting, drain pipes, lighting, etc. If any defect is found, it should be repaired as soon as possible.

C. In the case of metal overpasses, repainting is required after an appropriate period.

8.2.7 Sidewalk and Bicycle Path

(1) Technical Guidelines

a) Summary of Warrants

1) Sidewalk

Traffic volume on outer lanes of both directions per day is 3,000 or more and pedestrian volume is 250 or more. For the roads in urban areas, it is desirable, regardless of the above traffic volume, to construct sidewalk on any road, when found necessary to do so and no land acquisition problems exist.

2) Bicycle-pedestrian path
(Bicycle path permissive of pedestrian traffic)

- Traffic volume on outer lanes of both directions per day is 2,000 or more and bicycle volume per day is 1,000 or more, or

- Traffic volume on outer lanes of both directions per day is 2,000 or more and bicycle volume per day is 500 or more, when vehicle speed is considerably high.

3) Sidewalk plus bicycle path

The total volume of pedestrians and bicycles exceeds 3,000 per day.

Note : Where two or three of the above warrants are satisfied simultaneously, the priority is in order of 3), 2) and 1).

(2) Engineering Specification

a) Minimum Width of Pathway

Assuming the occupied width of a pedestrian is 0.6m, the unit width of a row of pedestrians (that may be called as a "lane") shall be 0.75m including marginal spaces. Although the occupied width of a bicycle is the same as that of pedestrian, a unit "lane" width of bicycle requires 1.0m because of the unstable lateral positioning. The minimum widths are summarized in Table 8.10.

Table 8.10 Minimum Width of Pathway

Unit : m

Slow Traffic Path / Road Class	Bicycle Path	Bicycle-Pedestrian Path	Sidewalk
Urban Road	2.0 (1.5)	3.5 (2.0)	3.0 (1.5)
Other Roads	2.0 (1.5)	2.0 (1.5)	1.5 (1.0)

Note : Reduced values in the parentheses shall be applied when (1) volume of slow traffics (pedestrian or bicycle) are relatively small, or (2) planned on bridge longer than 50m.

b) Shoulder

Except for the space for planting, 0.5m wide shoulder is enough for respective purposes in most cases. Planting space may require 1.0 to 1.5m. It can be said, however, that the width may be reduced to 0.25m on bridges or on the sections under specific restrictions.

c) Vertical Clearance

The height of a cyclist or a pedestrian can be assumed less than 2.0m. Accordingly, vertical clearance of 2.5m for the bicycle(-pedestrian) path and the sidewalk is recommended.

d) Separation Methods

There are varieties of measures to separate slow traffic from high speed traffic. They vary from the simple one of edge line marking to the complete one of raised path with a guard fence and planting.

e) Pavement of Sidewalk

In principle, every sidewalk should be paved in order to provide a good walking surface for pedestrians as well as preventing dusts. Several methods can be used for the pavement of sidewalks as shown below.

- Asphaltic concrete pavement
- Colored asphaltic concrete pavement

- Cement concrete pavement
- Block pavement
- Interlocking block pavement

f) Treatment for Handicapped People

The following treatments might be required in areas where some handicapped people are thought to use pedestrian facilities.

- Guide block for blind people
- Slope on sidewalk

g) Treatment of Bicycle Path at Intersection

The concept of the treatment of bicycle path at intersections is summarized below.

A. To clearly show bicycle paths at intersections.

B. To avoid unnatural detours by bicycles.

C. To provide channelization markings for bicycles in order to guide bicycles approaching intersections away from the carriageway.

D. To separate intersecting corners from carriageway as much as possible. This treatment is necessary to avoid accidents between bicycles and left turn vehicles.

E. To clearly mark bicycle paths so that children can easily understand the bicycle path.