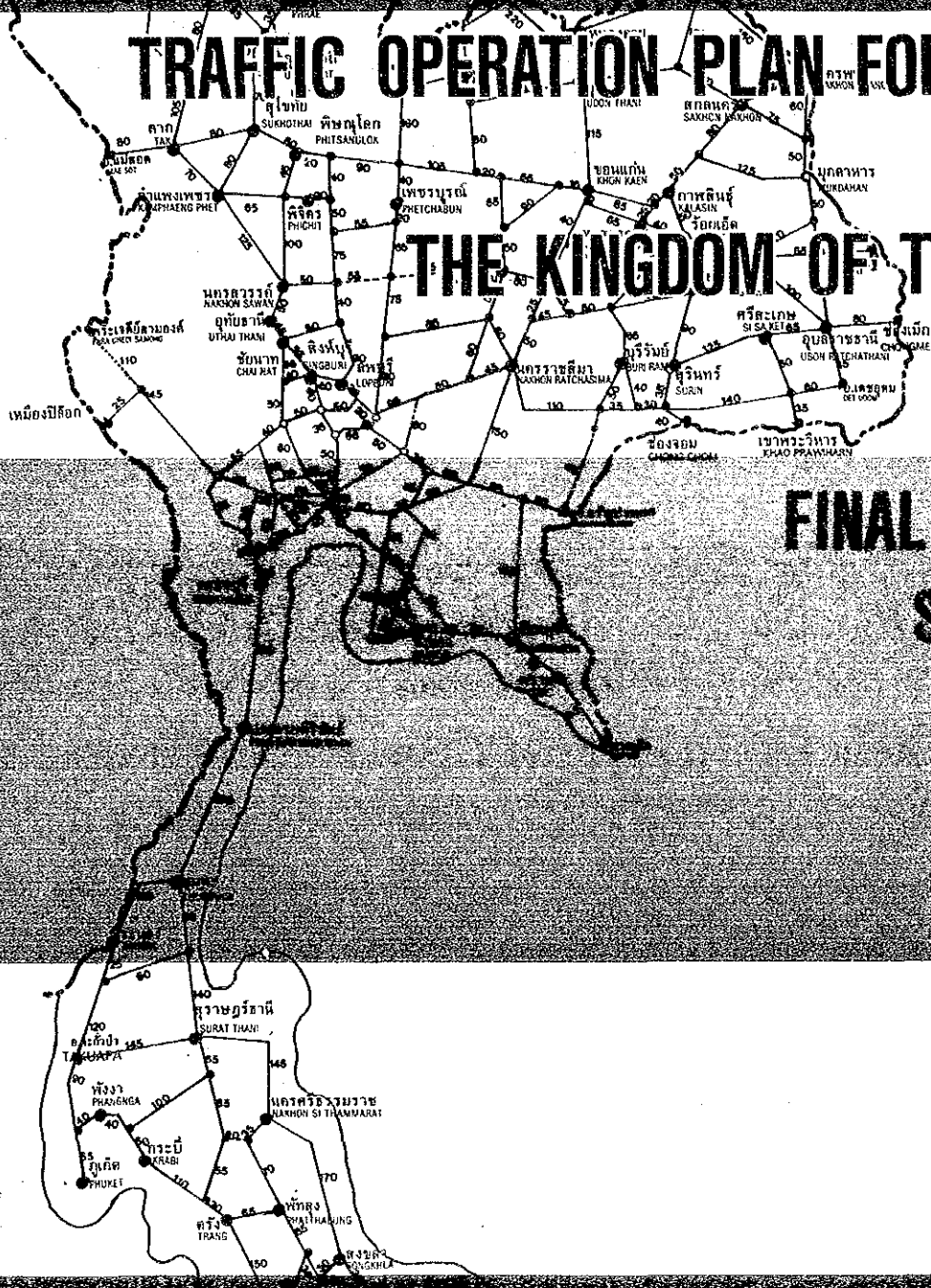
社会開発調査部報告書

TRAFFIC OPERATION PLAN FOR ROADS IN THE KINGDOM OF THAILAND



FINAL REPORT

SUMMARY

JUNE 1990

TRAFFIC OPERATION PLAN FOR ROADS IN THE KINGDOM OF THAILAND
FINAL REPORT
SUMMARY
JUNE 1990

THE STUDY ON TRAFFIC OPERATION PLAN FOR ROADS IN THE KINGDOM OF THAILAND

FINAL REPORT
SUMMARY

JUNE 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

P R E F A C E

In response to a request from the Government of the Kingdom of Thailand, the Japanese Government decided to conduct a study on the traffic operation plan for roads in the Kingdom of Thailand and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a survey team headed by Dr. Kaoru Ichihara, Central Consultant Inc., composed of members from Central Consultant Inc. and Oriental Consultants Co., Ltd. four times, from February to March 1989, from June to August 1989, from November to December 1989, and from February to March 1990.

The team held discussions with the concerned officials of the Government of Thailand, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

June, 1990

Kensuke Yanagiya

President

Japan International Cooperation Agency

LETTER OF TRANSMITTAL

June, 1990

Mr. Kensuke YANAGIYA
President
Japan International Cooperation Agency
Shinjuku Mitsui Building,
Nishi Shinjuku 2-1,
Shinjuku-ku, Tokyo,
JAPAN

His Excellency,

It is our great pleasure to submit herewith the Report of the Study on Traffic Operation Plan for Roads in the Kingdom of Thailand.

This report is the result of studies carried out by the Study Team consisting of Central Consultant Inc. and Oriental Consultants Co., Ltd. of Japan. During the service period, the Study Team conducted various studies related to the traffic operation for roads under jurisdiction of the Department of Highways in the Kingdom of Thailand.

The Study Team has completed the above service with a firm belief that implementation of above plans will substantially contribute to the improvement of the very serious road traffic problems on roads under jurisdiction of the Department of Highways, in particular the heavy traffic congestion and frequent occurrence of traffic accidents.

Our gratitudes are due to Japan International Cooperation Agency, the JICA Advisory Committee, Ministry of Foreign Affairs, Embassy of Japan in Thailand as well as officials and individuals of Thailand for their assistance extended to the Study Team.

In conclusion, the Study Team sincerely hopes that the study results would contribute to socio-economic development and well being in general and to the future traffic operation in the country.

Yours faithfully,

K. Ichihara

Dr. Kaoru ICHIHARA
Team Leader
The Study on Traffic Operation
Plan for Roads in the Kingdom
of Thailand
(Central Consultant Inc.)

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Background

The road traffic on the highway network is posing one of the serious social problems in Thailand as the degree of difficulties associated with the traffic is increasing at a rapid pace along with the growth of the volume of motor vehicles. Traffic congestion is becoming serious, particularly on the roads under the jurisdiction of the Department of Highways (DOH) in the suburban area of the Bangkok Metropolitan Area and in the areas surrounding the major local cities.

DOH has been aware of the urgent need to improve efficiency of traffic operations on the DOH highway network as well as to increase traffic safety. In this connection, the Study for the Traffic Safety Plan for Roads in the Kingdom of Thailand (the Phase I Study) was carried out by the Japan International Cooperation Agency (JICA) between 1983 and 1985.

The Government of the Kingdom of Thailand (GOKT) requested the Government of Japan (GOJ) to undertake the Study on Traffic Operation Plan for Roads in the Kingdom of Thailand (the Study). The decision was taken by GOJ to undertake the Study in response to the request of the GOKT. JICA has set up a study team (the Study Team) to undertake the Study.

1.2 Objectives of the Study

(1) Objectives of the Study

The objectives of the Study are;

A. To establish an effective traffic operation plan for the existing DOH roads by means of various measures discussed in the Study, namely;

- Physical improvement of roads including installation of traffic control devices.
- Application of traffic information system based on the studies on road inventory system, traffic census system, experimental works for traffic control measures, etc.
- Preparation of engineering specifications for various traffic safety devices and traffic control devices.

B. To perform technology transfer to the DOH counterparts in the course of the implementation of the Study.

(2) Definition of Traffic Operation System and Plan

In the Study, traffic operation is defined in rather narrower sense to cover only those study items specified in 1.3, which is considered to be the minimum requirement for DOH to identify the road sections having traffic problems on their existing road network, and to apply adequate measures for achievement of the objective of traffic operations.

1.3 Study Items

The main study items are classified into the following seven (7) groups taking into account the characteristics of the study items.

1) Review and Preliminary Survey

- Collection of data and information.
- Review of roads and traffic conditions.
- Review of traffic operation systems.

2) Identification of Problem Sections on DOH Roads

- Identification of locations and elements.
- Field survey.

3) Traffic Safety Measures

- Setting up engineering specifications for traffic safety devices

4) Traffic Control Measures

- Setting up guidelines for traffic control devices.
- Setting up engineering specifications for traffic control devices.

5) Experimental Works and Case Study for Traffic Control Measures.

- Field survey.
- Experimental works.
- Case study works.
- Execution of experimental works by DOH.
- Effective assessment of experimental works.

6) Traffic Operation Systems

- Formulation of traffic information system.
- Formulation of road inventory system.
- Formulation of traffic census system.
- Establishment of traffic operation system.

7) Recommendations

- Recommendation for traffic operation organization.
- Recommendation for traffic operation plan.

1.4 Reports

The following reports were submitted or are to be submitted to DOH.

- Inception Report	: February, 1989
- Interim Report (I)	: July, 1989
- Interim Report (II)	: December, 1989
- Draft Final Report	: February, 1990
- Final Report	: June, 1990

2 CURRENT CONDITION OF DOH'S TRAFFIC OPERATION SETUP

2.1 Present Socioeconomic Condition in Thailand

The total population of the whole country is about 55 million and the population density is 107 person/km^2 in 1988. Bangkok Metropolitan Area has the highest population density (5,437 person/km^2). The population growth rate of the whole country has decreased from 2.4% in 1985 to 2.0% in 1988, except in the Bangkok Metropolitan Area.

The Bangkok Metropolitan Area shows the highest per capita GRDP of about 60,000 Baht, which is almost 3 times as large as that of the whole country. On the other hand, the Northeastern region shows the lowest of about 15,000 Baht, one-forth of Bangkok Metropolitan Area.

2.2 Existing Road Conditions

The total length of roads controlled by DOH is approximately 49,800 km as of 1988. The status of national and provincial highways in 1988 by region indicates the following:

A. The length of paved roads per 1,000 persons is 0.653 km for the nation as a whole. By region, the Southern Region has the highest ratio at 0.963 km.

B. The density of paved roads is 0.07 km/km^2 nationwide. By region, both the Southern Region and the Central Region have the highest density at 0.093 km/km^2.

C. The total length of roads under construction or planned for construction is roughly 8,000 km nationwide. Within these new planned roads, 3,952 km will be constructed in the Northern Region, which has the lowest density of paved roads at present.

2.3 Motor Vehicle Registration

The total number of motor vehicle registrations increased annually by 16.3% from 2.6 million in 1982 to 6.4 million in 1988. Passenger cars have increased annually by 12.9% since 1982 to 816 thousand in 1988, while motorcycles have also increased annually by 18.6% in the same period.

2.4 Current Traffic Conditions

(1) Traffic Volume

Traffic volume on trunk roads in the Bangkok Metropolitan Area are extremely high. Average daily traffic in nearly all sections of major trunk roads within the area exceeds 50,000 vehicles, while traffic volumes in surrounding areas are also generally high at 10,000 - 30,000 vehicles per day. In outlying areas, fairly high volumes are seen on national and provincial highways near major cities, but between cities traffic is light.

(2) Traffic Accident

Traffic accidents in the country rose from about 15,500 in 1982 to 35,000 in 1988 giving an average annual increase of 14%. Particularly, number of traffic accidents drastically increased in 1988. The accident rate on roads managed by the DOH declined from 16.5 in 1981 to 9.2 in 1988.

(3) Current Condition of DOH's Traffic Operation Setup

a) Traffic Conditions

Of the 48,000 km of roads in the nation, only about 450 km mainly in and around the highly-congested Bangkok area are four-lane roads. The rest are two-lane roads. DOH roads experience several problems, as listed below.

- Congestion in and around Bangkok
- Congestion in rural cities
- Congestion caused by motorcycles
- Pedestrian safety

b) Traffic Control and Traffic Safety Facilities

DOH has made great efforts to install traffic control as well as traffic safety facilities on its highways. However, several problems can be pointed out for the following facilities as well as installation methods.

- Traffic signals
- Traffic signs
- Road markings
- Delineators and road studs
- Street Lighting
- Guard fence
- Vehicle detectors

2.5 DOH Budget

Over the past ten years, the DOH budget has doubled. The DOH budget for 1989 is 12 billion Baht, which accounts

for 87% of the entire MOTC budget. This large allocation of the MOTC budget to DOH indicates that the highway network under the jurisdiction of the DOH is playing a key role in support of the Thai economy.

The allocation of DOH budget for maintenance of highways has been increasing in recent years. Road maintenance works are predicted to increase more and more in the future. This is due to the expansion of highway network in addition to the improvement of road service level.

2.6 Review of the Phase I Study

(1) Experimental Works

Experimental works in the Phase I Study were implemented at eight hazardous locations of DOH roads in 1984. Considering the present traffic conditions, some counter measures look like rather faded out and further measures were taken at three sites. However, the remaining counter measures taken at five sites still remain effective.

(2) Case Study

In the Phase I Study, total length of 41.4 km (17 locations) sampled from 11 routes was selected as the Case Study roads. Follow-up survey of the case study in the Phase I Study was carried out to make clear how the selected case study sections were improved in compliance with the plans recommended in the Phase I Study.

2.7 Review of the Highway Accident Prevention Project

"Highway Accident Prevention Project" is one of the main projects in "Five years Plan for Construction and Rehabilitation of Highways (1987-1991)". To provide safety to road user, this project started with the total budget of six hundred and five million baht since fiscal year of 1987. According to the investment schedule of DOH, the year- to-year investment amount is quite similar to the investment schedule recommended in the Phase I Study. It indicates that the Phase I Study has been put to practical use.

3 IDENTIFICATION OF PROBLEM SECTIONS ON DOH ROADS

3.1 Basic Concept of Identification of Problem Sections on DOH Roads

Understanding the traffic conditions on the roads, problems and problem sections are comprised of multiple factors, such as the fundamental traffic flow elements consisting of traffic volume, vehicle speed, and density, driving amenity, which is very difficult to be expressed numerically, and also on the minus side the traffic accidents and environmental pollution. Therefore, evaluation of traffic conditions on the roads having a variety of characteristics may change a viewpoint in accordance with the traffic situations on the roads. Generally the main evaluation items are as follows:

- Smoothness
- Safety
- Amenity
- Accessibility
- Economical efficiency
- Environmental protection

The aim of the Study is to understand and evaluate the traffic situation macroscopically and objectively from the viewpoint of the road administrators. In the Study, smoothness and safety are to be evaluated because the related data can be collected and a numerical and reliable analysis is available. The basic concept of the evaluation from the viewpoint of traffic smoothness and traffic safety are described as follows:

(1) Smoothness Evaluation

Smoothness of the traffic is mainly represented by travel speed on the road sections under examination.

In the case of evaluating traffic situations on roads using traffic volume, traffic volume to traffic capacity ratio at each road section can be a useful indicator. Traffic volume to traffic capacity ratio not only indicate traffic congestion rate, but also have an advantage of providing some correlation between traffic volume and travel speed. Accordingly, in the Study, traffic congestion rate is to be used as an indicator for traffic smoothness.

(2) Safety Evaluation

If the traffic accidents which occurred during certain periods are recorded in a map of the roads by affixing identifying tags, then similar types of the traffic accidents may be concentrated at specific points. Such

frequent traffic accident points on the roads are usually called hazardous locations. In the Study, the hazardous road sections are extracted by identifying the hazardous locations. Accordingly, the traffic accident rate is used as an indicator of traffic safety.

3.2 Identification of Problem Sections through the Traffic Congestion Rate

In the Study, traffic volume to traffic capacity rate, namely, traffic congestion rate is determined to apply as an index of smoothness. DOH roads are classified into non intersection (roadway) and intersection. However, in order that traffic capacity on the intersections may be calculated, the detailed data of operating traffic lane and traffic phase on each intersection are necessary. As it is very difficult to collect completely these data in the Study, the objects of identifying problem sections are determined to apply to only non intersections (roadway sections).

(1) Method of Calculating Congestion Rate

A method applied in Japan is adopted in the Study to calculate traffic capacity for obtaining the congestion rate. The reason for adopting a method applied in Japan is that there is not enough accumulation of data for determining specific traffic capacity applicable to Thai situation and there also is no ground for using values applied in the United States. The method used for calculating congestion rate is illustrated in Figure 1.

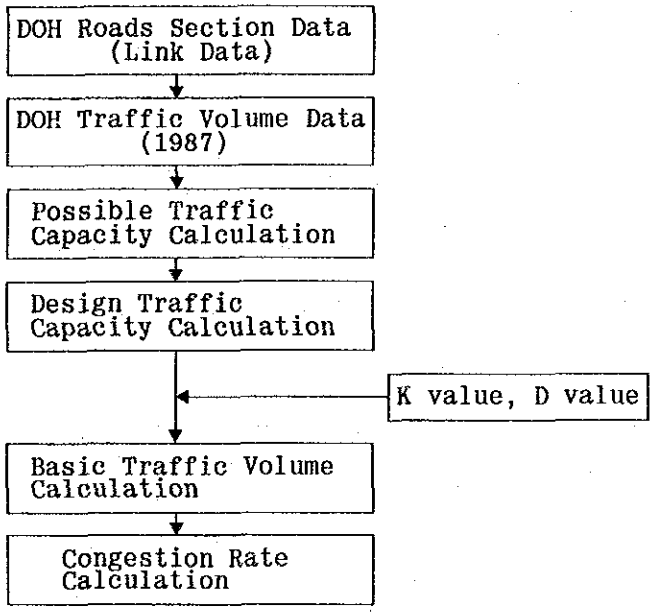


Figure 1 Traffic Congestion Rate Calculation Flow Chart

(2) Identification of Congested Road Sections

The DOH roads' traffic congestion rate is calculated by the methods shown in (1) using the data for 1987. The control sections which were not subjected to actual traffic volume observations were not analyzed. The roadway is broken down to road sections on the following basis:

A. Traffic volume observations which were conducted each year by DOH are carried out basically on one point in each control section. Accordingly, while only one observation point in one control section is set up, it is deemed to be one road section in one control section.

B. In case of one control section which has two and more traffic volume observation points, a central point is deemed to be a road section border.

The calculated traffic congestion rate is shown in Table 1. The followings are understandable from this table.

Table 1 Non Intersection (Roadway) Traffic Congestion Rate (By type of road)

Unit : m

Congestion Rate : a	Primary Highway	Secondary Highway	Provincial Highway	Total
0 ≤ a < 0.25	2,659,721	4,833,936	23,753,546	31,297,205
0.25 ≤ a < 0.50	1,903,668	1,063,911	919,701	3,887,280
0.50 ≤ a < 0.75	376,598	219,951	240,992	837,541
0.75 ≤ a < 1.00	382,923	87,276	31,713	501,912
1.00 ≤ a < 1.25	63,970	6,360	22,608	92,938
1.25 ≤ a < 1.50	19,080	0	13,142	32,222
1.50 ≤ a	74,099	45,853	0	119,952
Total	5,480,059	6,307,289	24,981,702	36,765,050

A. Road sections which show a congestion rate greater than 1.0 amount to a total length of approximately 245km representing 0.7% of total length analyzed.

B. By contrast, road sections which have a congestion rate of less than 0.5 represent a total length of approximately 35,200km or 95.7% of total length analyzed.

C. Road sections which have a congestion rate of more than 1.25 total approximately 150km or about 0.4% of total length analyzed.

D. Traffic congestion rate on Primary Highways appears higher than other road types which were analyzed.

E. Division 410 (Bangkok Highway Division) and Division 430 (Lop Buri Highway Division) which are located in central Thailand show a high traffic congestion rate among the regional observations.

3.3 Identification of Problem Sections through Traffic Accident Rate Analysis

In the Study, hazardous road sections can be defined as sites where traffic accidents occur frequently or a large number of casualties exists indicating some remedial measures are required. However, "hazardous" is always defined relatively and not absolutely.

In the Study, accident rate - traffic volume method, which was recommended in the Phase I Study and which has been adopted at DOH, is used. However, since the existing DOH data on intersections are unavailable, only roadways sections are analyzed through the accident rate - traffic volume method.

(1) Identifying Method for Hazardous Road Locations

Figure 2 shows the process of establishing identification criteria. This diagram describes the flow of the analytical process, data handling and processing to lead to the setting of identification criteria.

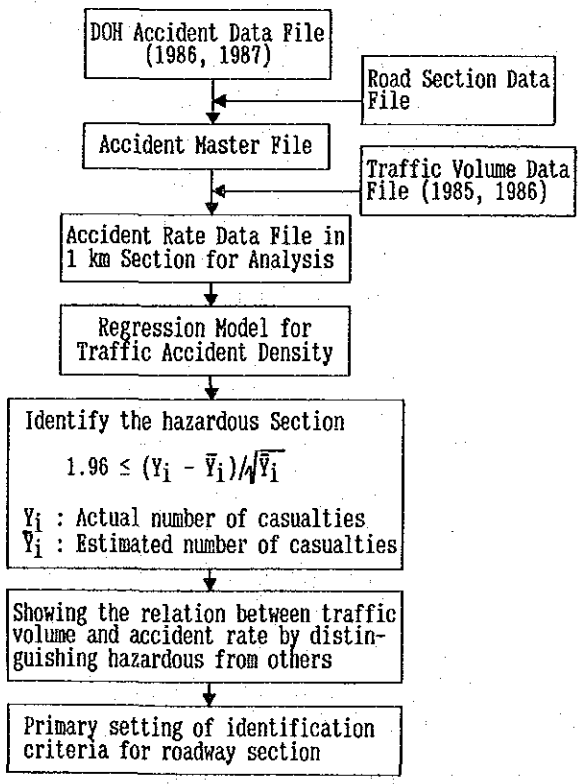


Figure 2 Process of Establishing Criteria

(2) Identification of Hazardous Road Locations

Using the methods previously explained and data of 1986 and 1987 on DOH roads, hazardous sections were identified by classification of roads. Identification of problem sections by the accident rate method was determined comprehensively taking into account the results of interview from district engineers, and the same method as identification of problem sections by the congestion rate.

Table 2 Length of Hazardous Road Locations by Road Classification

Unit : km

Road Classification		1986	1987
Primary Road	Route No. 1 - 4	74.7 (25)	72.5 (24)
	Others	41.6 (14)	38.5 (13)
Secondary Road		35.9 (12)	27.2 (9)
Provincial Road		24.4 (8)	26.5 (9)
Total		176.6 (59)	164.7 (55)

Note : Figures in parentheses indicate number of hazardous road locations.

4 CASE STUDIES AND EXPERIMENTAL WORKS FOR TRAFFIC CONTROL MEASURES

4.1 Objectives of Case Studies and Experimental Works

(1) Objectives of Case Studies

The general procedure to prepare the engineering remedial works at a certain location is as shown below;

A. Selection of location which require remedial works.

B. Collection and analyses of data pertaining to traffic condition and road condition.

C. Identification of major problems from traffic engineering consideration.

D. Determination of traffic control measures applicable to the selected location.

E. Detailed design of traffic control measures.

F. Estimation of improvement cost.

G. Preparation of the implementation program.

In the Study, execution of case studies is planned in order to show some examples of traffic control measures for engineering remedial works prepared according to the procedures outlined above.

(2) Objectives of Experimental Works

The objectives of the experimental works in the Study is to evaluate the effectiveness of the traffic control measures through before-and-after surveys of the experimental works. In the Study, the experimental works are considered to be a part of the case study for the traffic control measures. In addition, execution of the experimental works are fully incorporated with the establishment of the traffic operation system in DOH.

4.2 Selection of Locations for Case Studies and Experimental Works

Since it was almost impossible to pin point certain locations from the huge DOH road network, the representative areas for the Study was determined as follows and several locations from each representative area were selected for the case studies as well as experimental works.

A. Bangkok suburban area

B. Local city area

C. Intercity road section

The final selection of location was made in consideration of the following points;

A. Selected location should be a road section containing typical traffic operational problems in each representative area.

B. Since the case studies and the experimental works must be a kind of demonstration related to the traffic control measures, good effects of improvement should have been expected.

C. For the experimental work locations, it was necessary to consider the DOH's improvement program in the fiscal year 1988, because implementation of experimental works was agreed to be conducted by the DOH's own budget.

As a result, 5 locations and 4 locations were selected for the case study and the experimental work, respectively.

4.3 Supplemental Surveys

Since it was necessary to collect various data related to the site condition and traffic condition at each selected road sections for the case study and the experimental work, topographic surveys and traffic surveys were carried out by the Study Team.

4.4 Preparation of Case Study and Experimental Work Plans

Through the series of site investigations, supplementary surveys and data analyses, existing conditions and major problems were identified for each planning site, and then traffic operational measures for each planning site were planned in order to cope with major traffic operational problems. For the determination of traffic operational measures, the following points were taken into consideration;

A. The proposed measures should be expected to solve the traffic operational problems at each location.

B. The proposed measures should be acceptable in each representative area.

C. The proposed measures should be applicable to other areas in Thailand, where road and traffic condition are similar.

D. The consensus for the proposed measures should easily be obtained from relevant parties, such as drivers and police.

Tables 3 and 4 summarized the selected locations for the case study and the experimental work, and proposed traffic control measures.

4.5 Implementation

The experimental improvement works at four planning sites have been implementing by DOH with DOH budget. The improvement cost for the experimental work are summarized in Table 5.

Table 5 Summary of the Improvement Cost for the Experimental Works

Location	Route No.	Traffic Operational Measures	Improvement Cost (Mill. Baht)
E-1 Laksi Roundabout	R1/R304	- Installation of Signal - Pavement Marking	3.74
E-2 Pathumthani Intersection	R3111/ R346	- Installation of Signal - Provision of Added Lane	0.70 (only signal)
E-3 Khon Kaen	R2	- Provision of Motorcycle Lane	0.55 (only W=1.5m)
E-4 Khon Kaen	R2	- Provision of Passing Lane	3.44

4.6 Effectiveness Evaluation

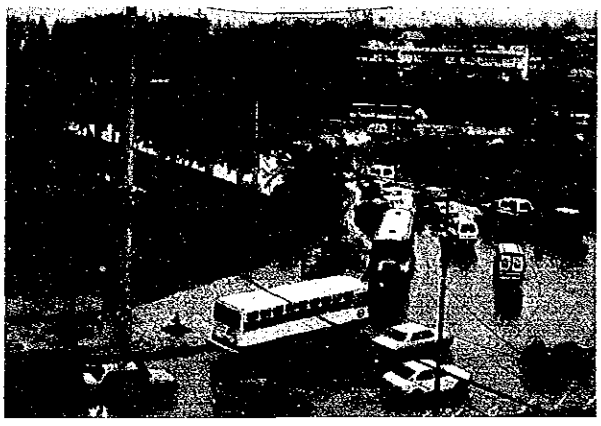
In the Study, the Study Team decided to adopt before- and after-surveys for the effectiveness evaluation of the experimental works by means of comparison of traffic conditions and traffic accidents between before and after implementation of planned improvement measures.

Unfortunately, the delay of the implementation of experimental works for the Laksi Roundabout and the passing lane in Khon Kaen, mainly because of the budgetary procedure and lacking of contractors, also cause the delay of the after-surveys.

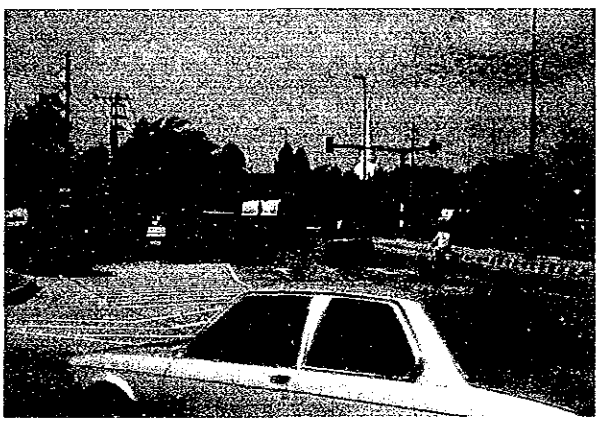
As the result, the effectiveness evaluation of experimental works for the motorcycle lane in Khon Kaen and the improvement of the Pathumthani Intersection were only carried out. The results of these effectiveness evaluation are summarized below.

(1) Motorcycle Lane in Khon Kaen

It was confirmed that the smoothness of vehicle operation as well as the safety condition along this road

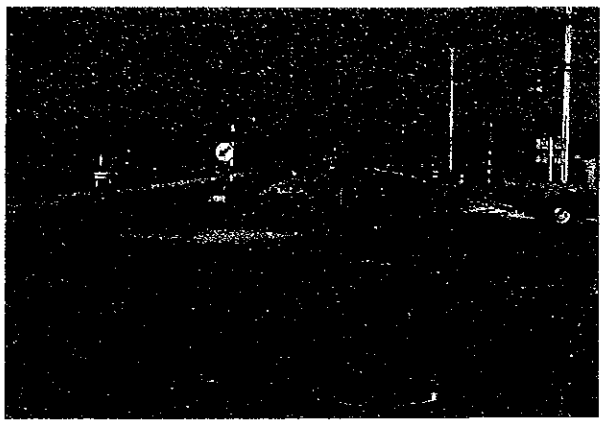


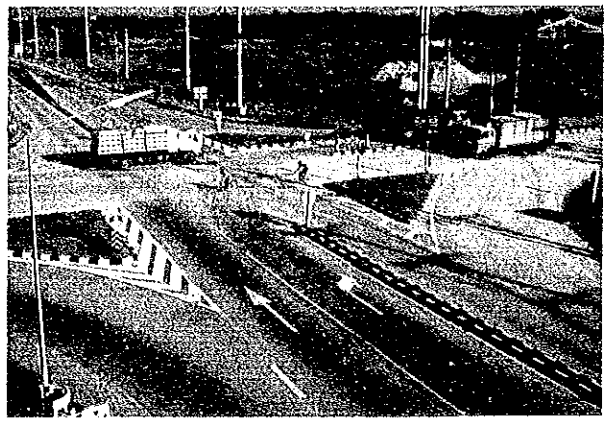
Before Implementation



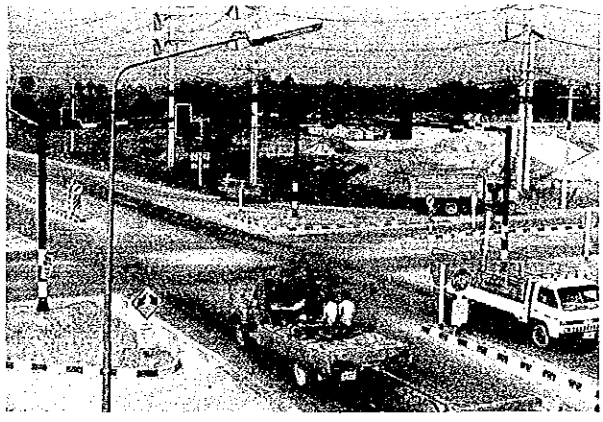
After Implementation
(Traffic signals are not in operation)

Photograph of Experimental Work Site
E-1 Laksi Roundabout





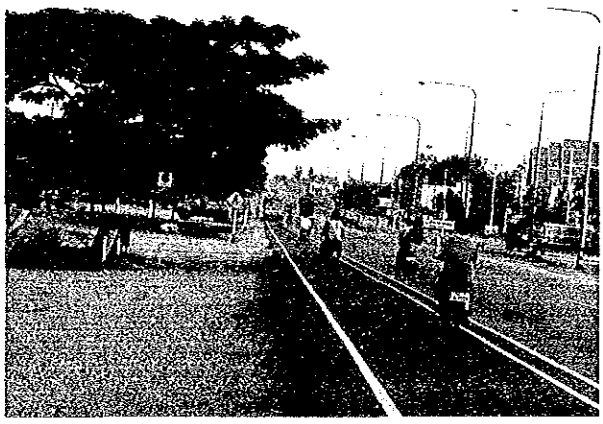
Before Implementation

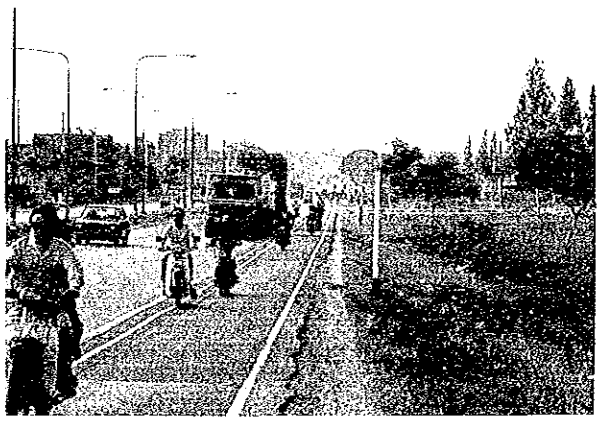


After Implementation

Photograph of Experimental Work Site
E-2 Pathumthani Intersection

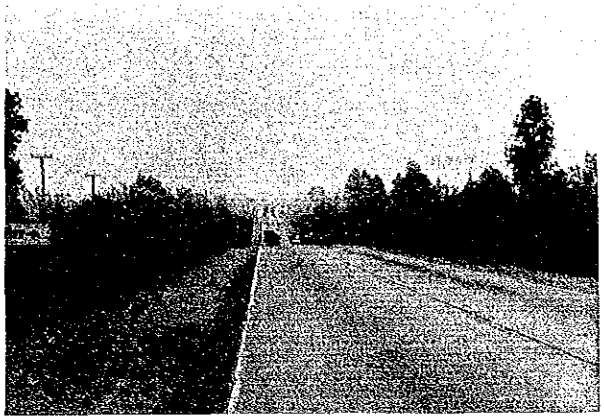
Before Implementation



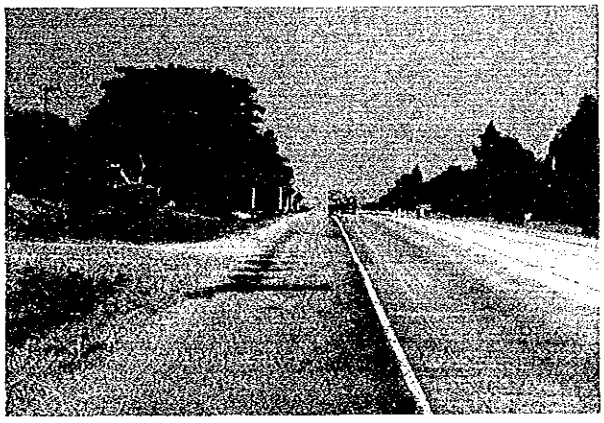


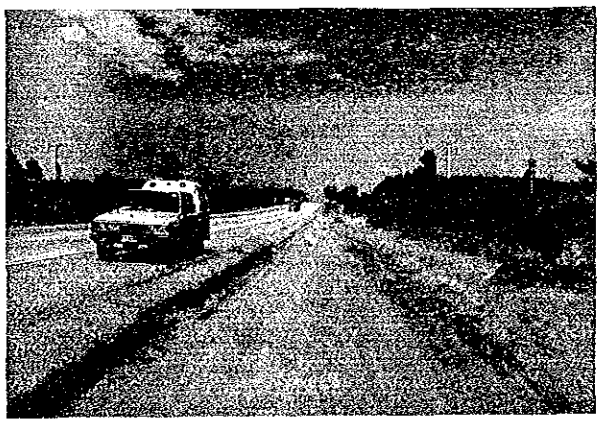
After Implementation

Photograph of Experimental Work Site
E-3 Motorcycle Lane in Khon Kaen



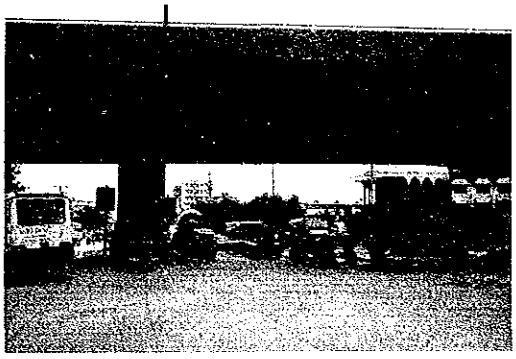
Before Impelementation





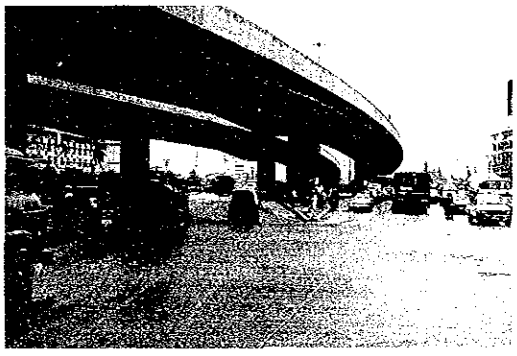
Under Construction

Photograph of Experimental Work Site
E-4 Passing Lane in Khon Kaen

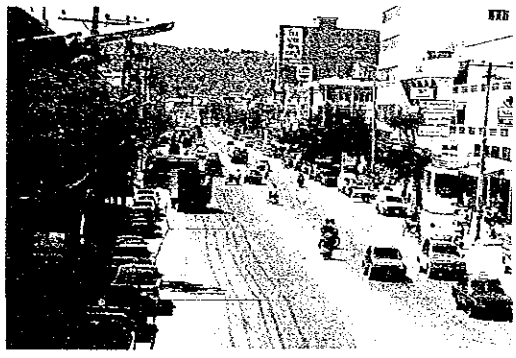


C-1 Bang Na Intersection (1)

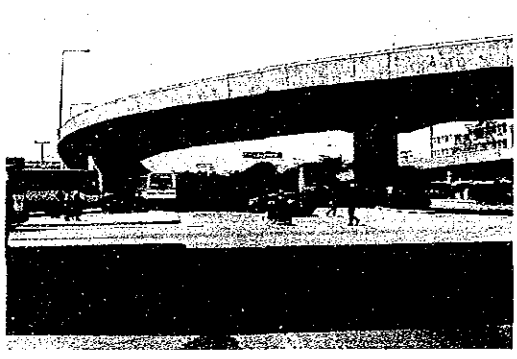
C-2 Chonburi (1)



C-1 Bang Na Intersection (2)



C-2 Chonburi (2)

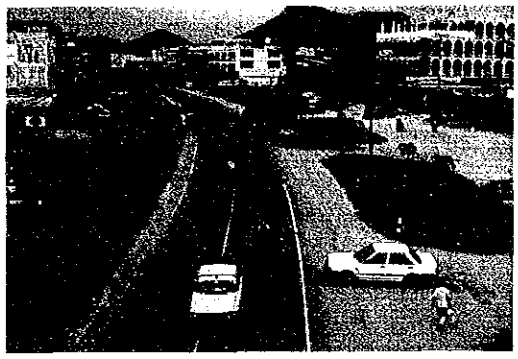


C-1 Bang Na Intersection (3)

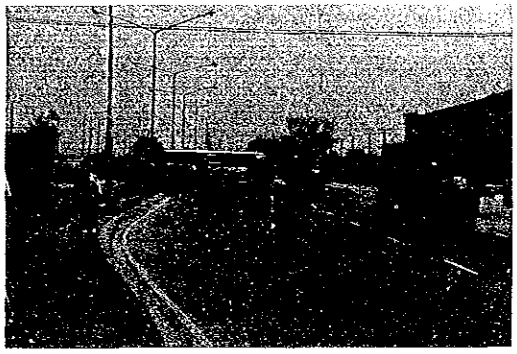
C-2 Chonburi (3)

Photograph of Case Study Site (1)

C-3 Sriracha Intersection (1)

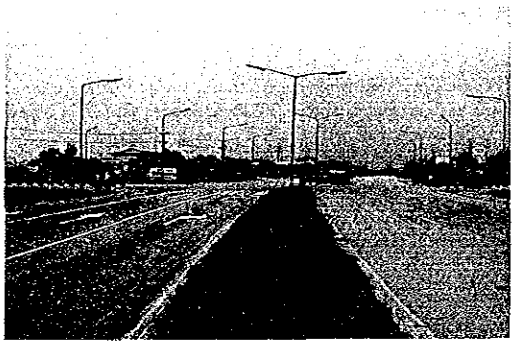


C-3 Sriracha Intersection (2)

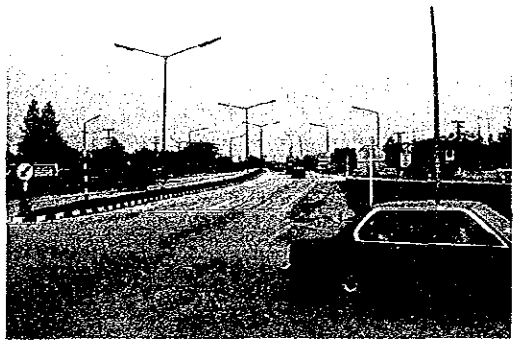


C-4 Wang Noi Intersection (1)

C-4 Wang Noi Intersection (2)



C-5 Ban Bung-Klaeng Intersection (1)



C-5 Ban Bung-Klaeng Intersection (2)

Photograph of Case Study Site (2)

Table 3 Summary of Case Study

Location No.	Route No.	Control Section	Section Name	Kilo Post	Area CD	Classified Area	Road Configulation	Major Countermeasure	Remark
C-1	R.34 (R.3, R.3102)	100	Bang Na	0+000-4+000	411	A	Signalized Intersection (Under elevated road)	* Rehabilitation of pavement * Improvement of visibility of signals * Modification of signal phasing * Extention of left turn lane	
C-2	R.3 (R.315, R.344)	402	Chonburi	92+000-94+100	422	B	Signalized Intersection Roadway	* Improvement of channelization * Installation of median * Modification of signal phasing	
C-3	R.3	501	Sriracha	95+100	422	B	Signalized Intersection (not operated)	* Improvement of visibility of signal * Channelization * Installation of median * Access control of frontage road	
C-4	R.1 (R.309, R.3189)	202-301	Wang Noi	65+151 - 167	413	C	Intersection (with partial frontage Rd.)	* Short term plan - Signalization - Improvement of frontage road - Channelization * Long term plan - Grade separation	
C-5	R.344 (R.331)	200	Ban Bung - Klaeng	31+506	422	C	Intersection	* Channelization * Speed control	

Classified Area. A : Bangkok suburban area
B : Local city area
C : Intercity roadways

Table 4 Summary of Experimental Works

Location No.	Route No.	Control Section	Section Name	Kilo Post	Area CD	Classified Area	Road Configulation	Major Countermeasure	Remark
E-1	R.1 (R.304)	100	Laksi	18+567	411	A	Roundabout	* Signalization * Channelization	
E-2	R.346 (R.3111)	100	Pathumthani	12+122	416	A	Intersection (4-leg)	* Signalization * Channelization * Installation of acceleration Lane	
E-3	R.2	1000	Khon Kaen	1+100-3+100	621	B	Roadway	* Motorcycle Lane	
E-4	R.2	1000	Khon Kaen - Nam Phong	14+25-15+500	621	C	Roadway	* Passing Lane	

Classified Area. A : Bangkok suburban area
B : Local city area
C : Intercity roadways

CLASSIFICATION OF TRAFFIC OPERATIONAL MEASURES IN E/W AND C/S

Intersection

a) Signalization	Laksi*, Pathumthani*, Wang Noi	3
b) Improvement of I.S	Ban Bung-Klaeng	1
c) Improvement of Signalized I.S	Bang Na, Chonburi, Srirach	3
d) Grade separation	Wang Noi, Laksi	2

Roadway

a) Access control	Wang Noi, Sriracha	1
b) Median	Chonburi, Sriracha	2
c) Adding lane	Khon Kaen*, Pathumthani*	2
d) Motorcycle treatment	Khon Kaen*	1

* means Experimental Work Sections

section was improved because of segregation of motorcycle traffic from the main traffic flow.

A. 63% of motorcycle used the motorcycle lane, 36% the first lane, and 1% the second lane. Based on the result of traffic volume counting for 12 hours, about 70% of motorcycles used the motorcycle lane.

B. The installation of the motorcycle lane has led to an increased running speed, hence improved smoothness. This tendency is evident particularly on the first lane.

C. The installation of the motorcycle lane helps to substantially reduce a potential danger involved with motorcycles running between cars on the first lane.

D. The central path of the motorcycle lane is most often taken (63% of motorcycles), which is followed by the first lane side path (30%). The video observation also confirmed that motorcycles were running steadily.

E. There was a significant reduction in the number of accidents and casualties, and it has been concluded that the motorcycle lane is serving its purpose well.

F. Most of users think that the installation of a motorcycle lane contributes significantly to reduced travel time, improved mobility and reduced accidents. 74% of motorcycle riders think the width of the motorcycle lane is adequate.

(2) Pathumthani Intersection

It was confirmed that the traffic smoothness as well as the safety level at the intersection were improved because of segregation of traffic flows by installation of traffic signals.

A. Results of the traffic behavior survey indicate the increase of running speed at the intersection by 10-25% after installation of traffic signals.

B. Total number of conflicts were reduced from 65 to 11, with the reduction rate of 83%. Particularly, conflicts between through vehicles and right turn vehicle were drastically reduced.

C. Number of accidents were reduced from 5 to 4, while side collisions were reduced from 4 to 0. All accident patterns after installation of traffic signals were rear-end collisions, but those collisions were not severe.

5 TRAFFIC CENSUS SYSTEM

5.1 General Traffic Volume Survey

The General Traffic Volume Survey consists of a Traffic Volume Survey and a Travel Speed Survey. The Traffic Volume Survey has been conducted by DOH since 1962 and it is desirable to improve the survey step by step. On the other hand, a Travel Speed Survey has not been implemented systematically so far. It is recommended to introduce this survey since it is very useful in identifying bottlenecks on DOH roads.

Travel Speed Survey is to be conducted annually on major routes by following the survey method proposed in the Study. The routes to be surveyed initially will be those with many control sections having high congestion levels as shown in the Report. Table 6 shows selected routes which need to be surveyed.

Table 6 Proposed Route for Travel Speed Survey

Route No.	Survey Section (Control Section)
Route 1	0001 0100 (Bangkok) - 0001 1202 (Nakhon Sawan)
Route 2	0002 0101 (Sara Buri) - 0002 1201 (Udon Thani)
Route 3	0003 0100 (Bangkok) - 0003 1200 (Chanthaburi)
Route 4	0004 0100 (Bangkok) - 0004 1100 (Prachuap - Khiri Khan)
Route 31/32	0031 0100 (Bangkok) - 0032 0802 (Chaint)

5.2 Motor Vehicle Origin-Destination Survey

Even though its value is unquestioned, it is very difficult to conduct an OD survey on a nation - wide basis. In Japan, when OD surveys were first introduced, it was only done in major city groups. At present, it is judged impossible to obtain enough survey staff to conduct a nation wide OD survey in Thailand. Therefore, for the time being, DOH should conduct OD survey locally and wait until a future time before conducting a survey on a nation-wide scale.

There are two ways to conduct OD survey locally.

1) Structure a city group with a major core city
2) Divide the country into blocks.

DOH is in control of all major trunk roads throughout the country and it is important that DOH is aware of nation-wide traffic flows. In the light of such an objective, method 1 is not recommended since it tends to focus on some major cities and may fail to reflect nation-wide traffic flows. Also such a grouping method 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, i.e. 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 present, 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.

5.3 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 to conduct the Continuous Traffic volume Observation Survey.

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 7 describes the functions of vehicle detectors installed along Route 31.

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, 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 7 Functions of Vehicle Detectors on Route 31

Items	Functions
Types	- 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

6 TRAFFIC INFORMATION SYSTEM

6.1 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:

1) Vehicle detectors
2) 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.

6.2 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.

6.3 Case Study Plan in Chonburi Area

(1) Software Configuration

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.

(2) Hardware Configuration

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.

7 ROAD INVENTORY SYSTEM FOR DOH ROAD

7.1 Inventory System for Traffic Engineering

Through the discussion with DOH staff in detail in view of traffic operation, management, planning and administrative works in TED, more than three hundred data items for the road inventory database were determined in detail for traffic engineering use. The database sufficiently covers the existing road database and is designed in such a way that no inconsistencies occur between them.

In the Study, in order to achieve improved traffic operation using the new database system as soon as possible, ten computerized database were recommended as shown in Figure 3. Meanwhile, considering the current data volume to be input into database, written inventory sheets in a form of table were also recommended for daily management works on traffic sign and road lightings in the district offices.

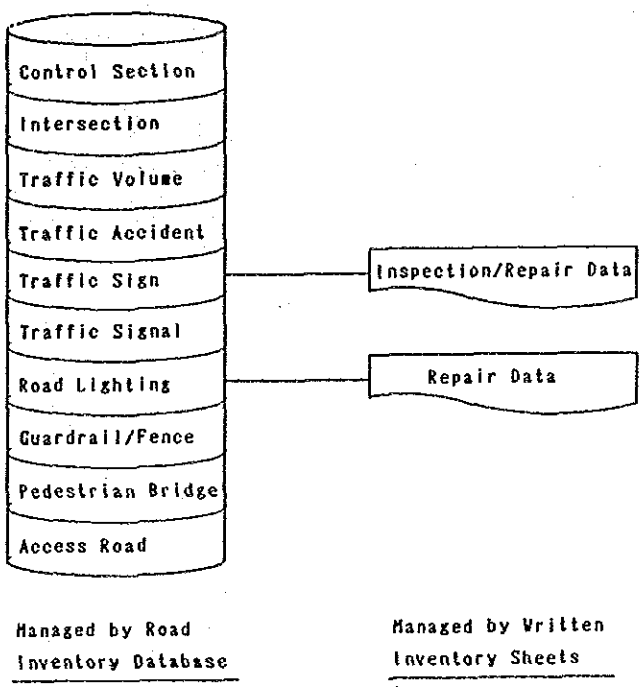


Figure 3 Road Inventory Database

The number of data items and of estimated records are summarized in Table 8. Total data volume is estimated at approximately 10 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 hindrance in load of the other system to the computer.

Table 8 Database Files 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 assumption considering in the current data condition and identification method.

7.2 Data Collection

In order to demonstrate the collection methods of inventory database and to make easily implementing the initial data collection, coding sheets for ten database files are prepared.

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

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".

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

- Median divider
- Facilities for channelization
- Added lane in the neighborhood of an intersection

2) Climbing Lane, Passing Lane and Motorcycle Lane

- Climbing lane
- Passing lane
- Motorcycle lane

3) Traffic Signal

- Warranting conditions
- Method to determine the signal phase and timing
- Concept for coordinated signal control
- Design of traffic signal control
- Installation of signal equipment
- Management of traffic signal operation

4) Traffic Sign

- Material of traffic sign
- Reflective material
- Illumination equipment
- Structure of traffic sign board
- Post of traffic sign
- Foundation and installation
- Inspection and Maintenance of traffic sign
- Traffic sign data book

5) Pavement Markings

- Basic requirement for the material
- Classification of materials and application method

6) Crossing Facility for Pedestrians

- Crosswalk
  * Warranting condition
  * Planning methods
  * Basic concept for designing a crosswalk
- Refuge island

  * Warranting condition
  * Planning method
- Pedestrian overpass
  * Warranting condition
  * Standard for pedestrian overpass design
  * Maintenance of pedestrian overpass

7) Sidewalk and Bicycle Path

- Warranting condition
- Minimum width of pathway
- Shoulder
- Vertical clearance
- Separation method
- Pavement of sidewalk
- Treatment for handicapped people
- Treatment of bicycle path at intersection

8) Street Lighting

- Warranting condition
- Lighting apparatus
- Lighting Pole
- Other equipments
- Installation process of street lighting
- Design of street lighting
- Design of wiring
- Installation
- Inspection
- Cleaning and maintenance
- Record

9) Delineator

- Post delineator
  * Warranting condition
  * Reflector
  * Supporting post
  * Installation
  * Routine inspection
  * Cleaning and maintenance
- Raised pavement marker
  * Warranting condition

10) Guard Fence

- Warranting condition
- Classification of guard fence
- Color
- Anti-corrosive treatment
- Installation method
- Inspection
- Maintenance
- Record

11) Pavement Treatment

12) Other Facilities
- Vehicle detector
- Road information system
- Bus stop facility
- Grade separation at railway crossing

9 TRAFFIC OPERATION PLAN

9.1 Traffic Operation System

(1) Traffic Obstacles in Thailand

This undertaking is concerned with DOH roads. DOH roads and related roads seem to have the following obstacles to traffic:

1) Traffic accident
2) Road disaster
3) Road improvement work
4) Abnormal weather
5) Traffic congestion

Accidents, disasters and improvement work represent traffic obstacles common to all roads,not limited to DOH roads. Abnormal weather poses a traffic obstacle accompanied mostly by torrential rain, sometimes with fog. Traffic congestion is caused by the concentration of traffic in the metropolitan area of Bangkok and other major cities across the nation at morning and evening peak hours. The traffic congestion is a constant occurrence.

(2) Traffic Operation Measures

The actual objectives of the traffic operation for countermeasures to the traffic obstacles mentioned above on DOH and related roads are as follows:

1) Easing of traffic congestion
2) Securing traffic handling capability in a state of traffic obstacles.
3) Effective road use.

Easing traffic congestion is to prevent or reduce traffic congestion. Securing traffic handling capability is to utilize detours to cope with traffic obstacles such as traffic accident. Effective road use is aimed at proper distribution of traffic volume on road network so as to avoid a localized concentration of traffic volume. These objectives should be achieved by application of the traffic operation methods.

(3) Traffic Operation System

The basic considerations in implementing the proposed traffic operation may be systematized in Figure 4.

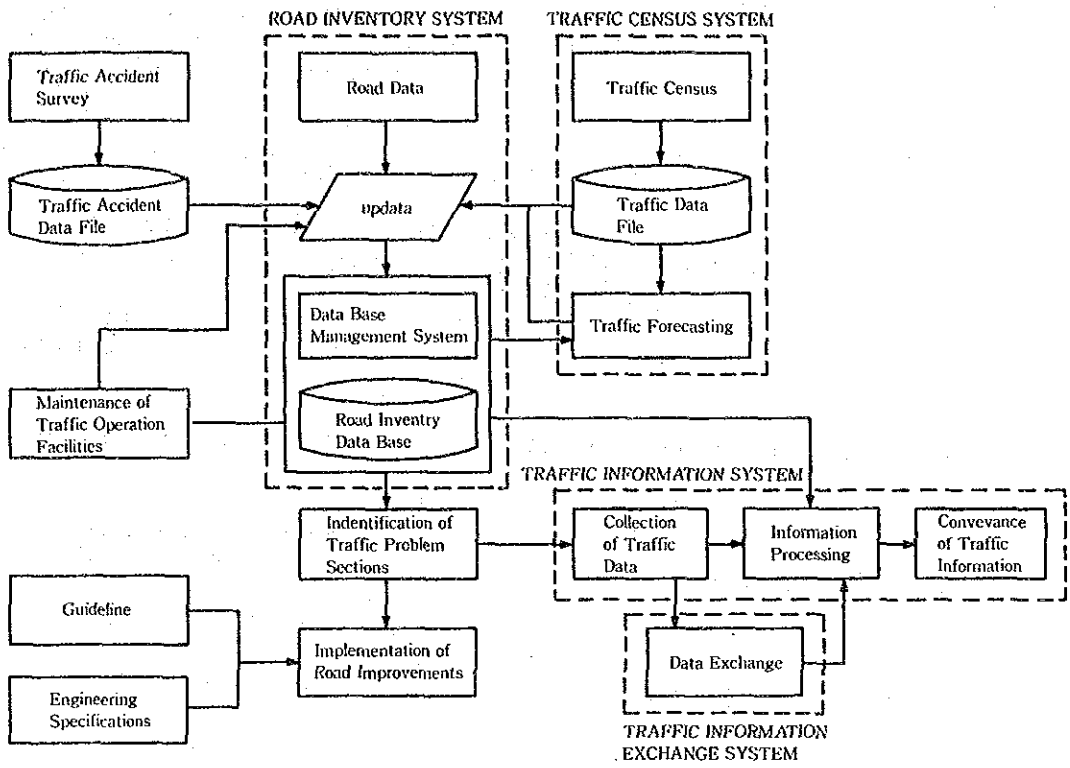


Figure 4 Traffic Operation System

9.2 Traffic Operation Plan

(1) Basic Concept of Traffic Operation Plan

There is no established definition as to traffic operation plan for achievement of safe, efficient and convenient travel of motor vehicles. The definition shall varies according to the purposes of the plan. In a broad sense, the plan for traffic operation is not only to formulate the direct and immediate measures and applications for traffic control by means of various devices, but also shall include the improvement of all the existing traffic functions comprising all the road facilities, traffic regulations and organizations, etc.

In the Study, however, the traffic operation plan is discussed on those physical measures to be applied on road facilities, such as motorcycle lane, passing lane and grade separated intersection, and traffic information system, which shall be implemented in a certain time span.

It is also to be mentioned that this report does not aim to present a plan itself, but the information needed for formulation of a traffic operation plan, and indication of the process to work out a plan through case study. From the planning period, the plan can be classified into two types, namely; masterplan with the time span of

about five to ten years, and action plan with shorter planning period with detailed scheme of implementation. The Study deals with a macroscopic masterplan on traffic operation.

(2) Method for Development of Traffic Operation Plan

The process and steps to formulate a traffic operation plan macroscopically are described as follows;

A. to select road sections or locations having traffic problems by identification methods with criteria by congestion degree and accident rate.

B. to classify the selected section or locations by road patterns and measure types.

C. to prepare standardized improvement measures corresponding to road patterns.

D. to apply each standardized measure to each classified road sections or locations, and to map out a macroscopic improvement plan for traffic operation.

E. to quantify the volume of the unit work for each type of improvement plan, and to estimate the cost required for implementation of the plan.

F. to sum up each type of improvement plan and to integrate to be a complete traffic operation plan.

G. to evaluate the formulated plan for traffic operation from the engineering viewpoint as well as from economic viability such as net benefit and benefit/cost ratio, together with the available financial resources.

As to the evaluation on the effectiveness of the formulated plan, it is possible to a certain extent to convert the benefit accrued from the investment such as saving of travel time, reduction in vehicle operation cost, saved life, prevented injury and property damage, etc., to monetary values, but it would be advisable to make a final decision in consideration of other factors like national policy and interest, development and improvement policy and strategy of road transportation and also DOH's policy and strategy for encouragement of traffic operations.

For formulation of a traffic operation plan, it is also important to verify the quantity and conditions of the existing traffic control and safety devices, and to work out the budget needed for replacement, repair and maintenance of such devices.

(3) Macroscopic Improvement Works Planning

In order to draw out a masterplan for traffic operation systematically and macroscopically, 64 selected road sections have been classified into four typical road patterns by road and traffic conditions for which four types of standardized improvement measures can be effectively adopted respectively.

As described in the preceding sections, there are four types of improvement work proposed in the Study;

A. Installation of motorcycle lane

B. Installation of passing lane

C. Provision of grade separated intersection

D. Provision of traffic information system

Therefore, the criteria for classification of road sections having various traffic problems to fit into four types of improvement work on traffic operation have been set forth as the following:

A. Congestion rate exceeding 0.50

B. Hazardous section selected by statistical method

C. Type of traffic problem to be congestion

D. Cause of traffic problem by ;

- Motorcycle .....Motorcycle lane
- Slower vehicle .....Passing lane
- Heavy traffic volume at intersection.....Grade separation
- Heavy traffic volume on road network .....Traffic information system

E. Degree of problem to be very high endorsed by district engineers of DOH.

F. Number of lane to be 1 lane each for both directions in cases of motorcycle and passing lane.

G. The selected road section is on roadway or the road section between intersections, for traffic information system.

With aforesaid criteria, 64 selected problem sections have been classified and fit into four types to which four proposed improvement works are to be adopted, namely; 20 sections for installation of motorcycle lane, 15 sections for installation of passing lane, 12 sec-

tions for provision of traffic information system, and 17 sections for provision of grade separated intersections.

(4) Effectiveness Evaluation

In the Study, the masterplan for traffic operation was evaluated by economic analysis in terms of net benefit (B - C) and benefit/cost ratio (B/C). In particular, it was made by the comparative assessment of the accrued total benefit by implementation of the masterplan in accordance with the implementation schedule spread over the period of 10 years, against the required installation cost and operating/maintenance cost distributed yearly according to the implementation schedule.

The conditions and assumptions for this evaluation were set as follows;

A. Evaluation period is assumed to be 20 years from the viewpoint of nature of the plan, its scale in work volume and cost, and the time required for completion.

B. The calculation was practiced with the constant prices at 1989 for costs and benefits with the assumption that price escalation rate is same for both costs and benefits. Also, for practical convenience, costs and benefits calculation was made without application of discount rate to achieve the net benefit and benefit/cost ratio.

C. The traffic volume and the number of casualties adopted for this evaluation was fixed at 1989 level for the practical convenience, although it might be possible to adopt those based on projection with annual increase for the plan period.

The economic evaluation reveals that by implementation of the masterplan for traffic operation, about 990 million Baht of net benefit (B - C) can be yielded with the benefit/cost ratio of 1.43 with the evaluation period of 20 years, justifying that this masterplan is economically feasible.

The result of economic evaluation from the first to 20th years are summarized in Table 9.

Table 9 Summary of Economic Evaluation

Year	Fiscal Year	Benefit (Mill. Baht)	Cost (Mill. Baht)	B-C (Mill. Baht)	B/C
1	1990	11.09	81.04	-69.95	0.14
5	1994	232.93	680.11	-447.18	0.34
10	1999	1,064.49	1,807.48	-738.99	0.59
15	2004	2,177.66	2,052.03	125.63	1.06
20	2009	3,286.83	2,296.58	990.25	1.43

(5) Summary of Traffic Operation Masterplan

The total amount of investment required for the masterplan for proposed traffic operation has been estimated at approximately 1,800 million Baht at 1989 prices, comprising 1,570 million Baht for installation/construction and 230 million Baht for replacement and operating/maintenance. This estimation was made on the condition that the masterplan were to be implemented over the period of 10 years from 1990 to 1999.

There are four types of improvement works proposed in the masterplan, namely; motorcycle lane would be installed at 20 road section, passing lane be installed at 15 sections, 12 traffic information systems would be provided at the selected road sections and 17 grade separated intersections be provided at the selected locations.

9.3 Traffic Operation Organization

(1) Internal Organization Mainly Aimed at Traffic Operation

Proposed improvement plan for divisions under control of the Deputy Director General for Engineering is shown in Figure 5.

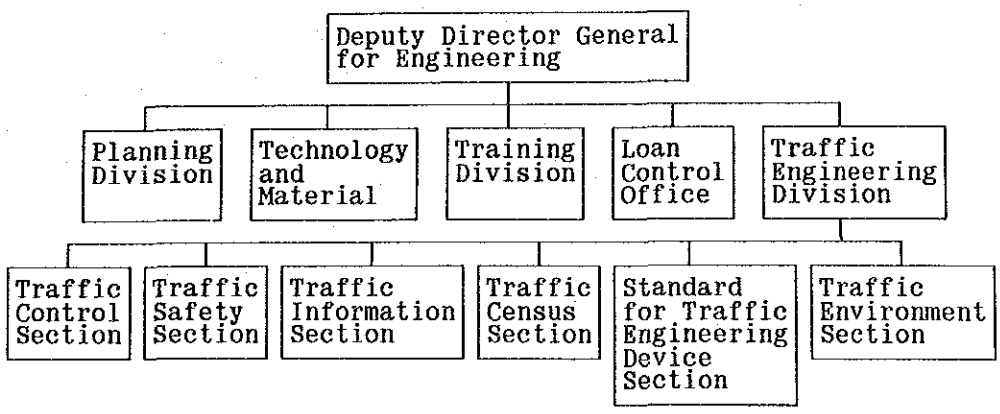


Figure 5 Proposed Traffic Operation Organization

(2) External Organization

In order to cope with advanced and complicated technology as well as to aggressively respond to the social requirement, it is desirable to establish the Research Laboratory and the Traffic Information Center as external bodies of DOH.

a) Traffic and Highway Research Laboratory

Proposed organization chart of the Traffic and Highway Research Laboratory is shown in Figure 6. In addition, expansion of this organization is desirable to be done gradually.

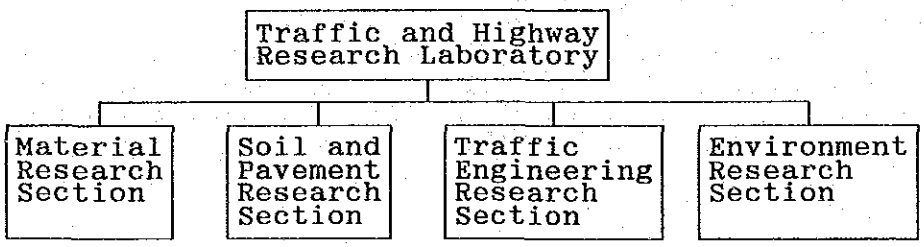


Figure 6 Proposed Organization Chart of the Traffic and Highway Research Laboratory

b) Traffic Information Center

The organization chart of proposed Traffic Information Center is shown in Figure 7. According to increase of tasks in the future, the organization is necessary to be expanded.

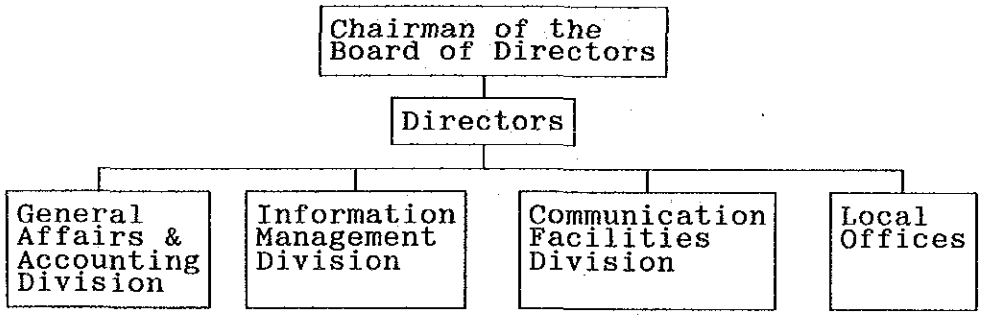
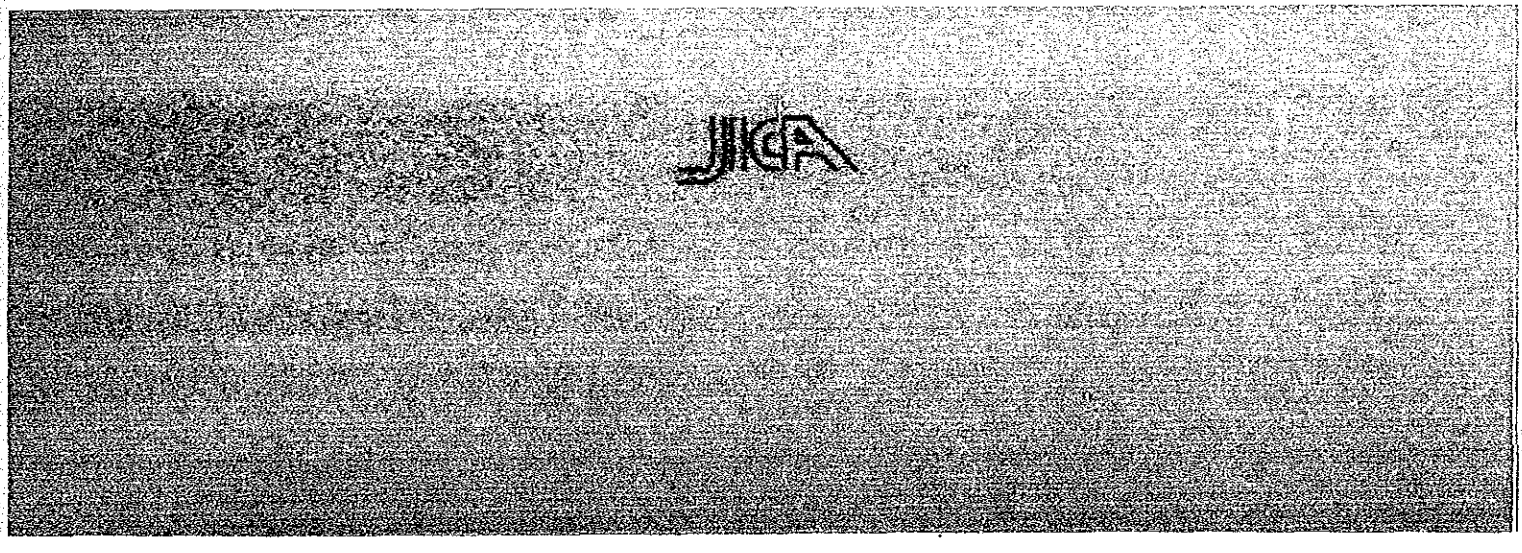


Figure 7 Organization Chart of Proposed Traffic Information Center


JICA