社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY

DEPARTMENT OF HIGHWAYS
MINISTRY OF TRANSPORT AND COMMUNICATIONS
KINGDOM OF THAILAND

FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS IN THE KINGDOM OF THAILAND

FINAL REPORT

VOLUME I
EXECUTIVE SUMMARY

MARCH 1995

KATAHIRA & ENGINEERS INTERNATIONAL
NIPPON KOEI CO., LTD.
KOKUSAI KOGYO CO., LTD.

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct the Feasibility Study on the Inter-city Toll Motorway Projects and entrusted the study to the Japan International Cooperation Agency (JICA).

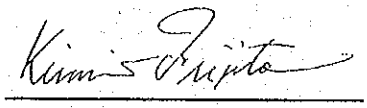
JICA sent to the Thailand a study team headed by Mr. Masahiko Tohi and Mr. Kunihiko Sawano of Katahira & Engineers International, and composed of members from Katahira & Engineers International, Nippon Koei Co., Ltd. and Kokusai Kogyo Co., Ltd. twice between August 1993 and March 1995.

The team held discussions with the officials concerned of the Government of the Kingdom of Thailand, and conducted field surveys at the study areas. 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 projects and to the enhancement of friendly relations between the 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.

March, 1995



Kimio Fujita
President
Japan International Cooperation Agency

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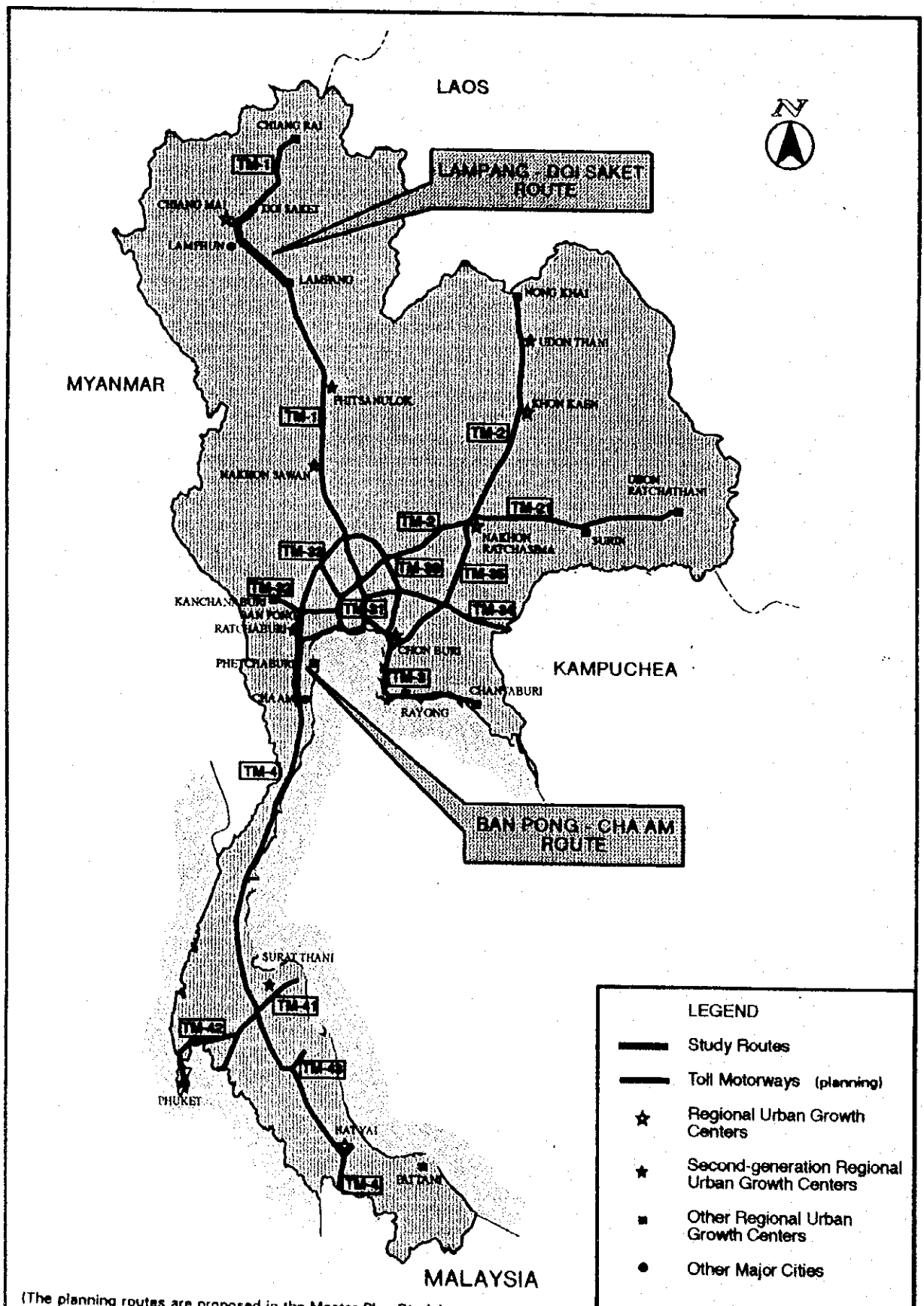
Exchange Rate (as of November 1994):

USD 1.0 = 25.01 Baht and 1.0 Baht = 3.926 Japanese yen



(The planning routes are proposed in the Master Plan Study)

FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	LOCATION MAP OF STUDY ROUTES

SUMMARY AND RECOMMENDATIONS

BACKGROUND AND OBJECTIVES

A nationwide inter-city toll motorway network of 4,300 km (the Network) was developed in the study titled "The Toll Highway Development Study in the Kingdom of Thailand" (the Master Plan Study) carried out by the Japan International Cooperation Agency (JICA) during the years 1990 and 1991.

The Network was developed to support the rapid growth in socioeconomic development and to create a multi-polar decentralized nation by bringing the benefits of motorways to everywhere in Thailand. As the construction of the motorways requires a huge amount of investment, a long-term stage construction implementation strategy should be formed. The concept of this long-term vision strategy should contain specific programs integrating management, construction, maintenance and operation systems for this motorway network.

This study is to investigate the technical, economical and financial viability of two high-priority motorway routes in the Network and to propose methodologies for implementation and operation.

OUTLINE OF THE PROJECT

Lampang-Doi Saket Route starts at the intersection with Rt. 1 in the southwest of Muang Lampang, runs through Amphoe Hang Chat of Changwat Lampang, Amphoe Mae Tha and Muang Lamphun of Changwat Lamphun, Amphoe Saraphi and Amphoe San Kamphaeng of Changwat Chiang Mai, and ends at Amphoe Doi Saket of Changwat Chiang Mai.

Ban Pong-Cha Am Route starts at the cross point of TM-32 (another proposed motorway) in Ban Pong municipality, runs through Amphoe Photharam, Muang Ratchaburi and Amphoe Pak Tho of Changwat Ratchaburi, Amphoe Khao Yoi, Muang Phetchaburi, Amphoe Ban Lat and Amphoe Tha Yang of Changwat Phetchaburi, and ends at Amphoe Cha Am of Changwat Phetchaburi.

OUTLINE OF THE PROJECT

Item and Description			Lampang - Doi Saket Route	Ban Pong - Cha Am Route
Geometric and Traffic Features				
Length			98.72 km	133.74 km
Design Speed	Flat/Rolling in Rural		120 km/h	120 km/h
	Mountainous or Urban/Suburban		100 km/h	100 km/h
Number of Lane			4-lane 2-way	6-lane 2-way
Average Daily Traffic	Year 2020 - veh/day		30,000 - 50,000	93,000 - 120,000
Structures				
Interchange	Number of Interchanges/Junctions		5	8
Other Facility	Number of Rest Areas		6	7
	Number of Bus Stops		8	10
Bridge	Number/Length of Bridges with:	L < 30m	11/196 m	55/652 m
		30m ≤ L < 100m	18/406 m	56/682 m
		100m ≤ L < 500m	1/100 m	-
Overbridge	Number of Overbridges in:	Flat area	26	42
		Mountainous area	7	-
Viaduct	Number/Length of Viaducts in:	Urban/Suburban	21/6,915 m	21/14,585 m
		Mountainous area	14/6,450 m	-
Crossing Structure	Number of Box culverts		291	400
	Number of Pipe culverts		26,599	51,423
Tunnel	Number (Length) of Tunnels		2 (3,800 m, 750 m)	0
Project Cost (Million Baht)*				
Direct Construction Cost			24,021	25,005
Maintenance & Operation			480	500
Land Acquisition			1,621	1,247
Engineering			1,441	1,000
Total			27,563	27,752
Economic/Financial Evaluation**				
EIRR			14.08%	23.02%
FIRR (Combined Pool System)			7.25%	

*, **Exchange Rates (as of November 1994): USD 1.0 = 25.01 Baht and 1.0 Baht = 3.926 Japanese Yen
Opportunity Cost of Capital in Thailand = 12%

PRELIMINARY DESIGN

The preliminary design covers all the geometric elements, structures and facilities necessary to assuring the toll motorway functions. Among structures and construction technology adopted in the design, concrete pavement, cut work in mountainous section, various slope protection structures, soil improvement work, tunnels and steel truss structure are highlighted in line of high civil engineering techniques which Thai engineers will make big challenge to achieve or technical assistance will be required for.

The concrete pavement structure is proposed here, with a certain execution control, because of its high availability and utilization of local materials. The execution control should be applied also for the huge-scale cut work required at some mountainous sections. Slope protection structures are introduced to be applied, based on detail geotechnical information, at both the cut and embankment sections. Along soft ground areas the proposed soil improvement works include the cement stabilization and filling control for low embankment sections and the bearing unit method for bridge approach sections with high embankment.

Design of tunnels along the motorways was based on the available data on the topographical and geological conditions and the construction method as well as the technical judgment. Steel truss structures are proposed to environmentally avoid the high embankment and the high piers for PC-box girder bridges.

MANAGEMENT AND OPERATION SYSTEM

The Study proposes that the construction and operation of the first sections of the motorway system should be executed by the DOH until a new state enterprise, tentatively named as the Inter-City Motorway Authority (ICMA), is created. This authority will have the maneuverability and flexibility to promote the activities of the motorway network and will provide the trustworthiness to acquire the required investment funds from various sources. It will have also the ease of reinforcing the project's management process and introducing a pool system to expand the motorway network as a national project. The ICMA is to be under the supervision of the Ministry of Transport and Communications (MOTC) with the specific objectives of financing, constructing and operating the 4,300 km network.

To develop policy and strategy and to study legal, economic and engineering issues, it is required to establish first a motorway organizing committee with the secretariat office at the DOH.

The organizational structure at division level of the ICMA can be divided into 11 divisions as per their respective coverage of 250 km to 600 km and the number of district offices is estimated to be approximately 90 offices in order to assure construction and operation activities including toll collection, maintaining of the network, controlling traffic and managing of traffic safety.

The applicable toll system should be the closed system based on the toll rate according to the distance traveled with the terminal charge being added for each motorway user as a fee for the usage of interchange facilities. The pool system is reasonable and adequate to maintain uniformity, consistency and equality of the toll system. Differences in the toll rate should be avoided within the network attributable to differences in the implementation time schedule and traffic volume, or to execute scheduled installment of loan repayment.

ENVIRONMENTAL CONSIDERATION

Appropriate mitigating measures should be applied to alleviate the negative environmental impact of project implementation, either during construction or after completion, based on the impact assessment on the 10 studied items of; air quality, noise, vibration, water resources and aquatic ecology, soil conditions, terrestrial ecology, transport network, land-use pattern, socio-economic conditions and cultural/aesthetic/archaeological values.

Along the Lampang - Doi Saket Route, special considerations should be applied to protect the water resources by avoiding the watersheds and to protect against the soil erosion by designing various soil protection structures. At Ban Pong - Cha Am Route, cement stabilization, bearing units and gradual embankment work should be provided to protect against ground subsidence. Maintaining the inter-community traffic and access is also a particular problem for all fully-access control motorways which should be deeply considered for the two routes.

ECONOMIC AND FINANCIAL EVALUATION

The project costs of both routes are estimated as follows:

- Lampang-Doi Saket Route (98.72 km):
  27,563 Million Baht (108.2 Billion Yen)
  Foreign Currency (F/C) = 61% and
  Local Currency (L/C) = 39%
- Ban Pong-Cha Am Route (133.74 km):
  27,752 Million Baht (109.0 Billion Yen)
  F/C = 47% and L/C = 53%

Estimated economic internal rates of return (EIRR) are 14.08% for Lampang - Doi Saket Route (L-D Rt.) and 23.02% for Ban Pong - Cha Am Route (B-C Rt.), which are in economically feasible ranges based on a discount rate of 12.0% as the opportunity cost of capital in Thailand. Financial internal rates of return (FIRR) are estimated as 2.57% for L-D Rt., 10.37% for B-C Rt. and 7.25% for combined pool system with L-D/B-C Rts. In consideration of realistic fund resources, combined pool system is recommended for effective implementation of the projects.

SOCIO-ECONOMIC EFFECTS

Reduction of the travel time by using motorways can enlarge the socio-economic zone and contribute to the promotion of the national and regional development. L-D Rt., for example, increases by 910,000 the population covered by 4 hours travel time to Chiang Mai. As a result, it produces such indirect effects as the promotion of various industries, the improvement of living conditions, the increase of resources, values and changes in land-use, and the improvement in productivity and transportation scheduling. The construction of motorways contributes also in creating new demands through road investments.

RECOMMENDATIONS

1. To implement the two motorway routes under this study in accordance with the schedule shown below, as they showed viability technically, economically and financially, in order to support the rapid growth in socio-economic development in Thailand.

2. To formulate a long-term stage-construction strategy, in order to complete the whole toll motorway network developed in the Master Plan Study. For this purpose, it is recommendable to establish a motorway organizing committee to develop policy and strategy and to study the required legal, economic and engineering issue.

3. To achieve an unburdened financial investment program with periodical revision of the toll rates and adopting the pool system to expand the motorway network. The study recommends also that the fund resource for the foreign portion can be obtained through low-interest-rate loans of international institutions, and the local portion through the national budget.

4. To apply the mitigating measures, proposed in this study, which are required to alleviate the negative environmental impacts of the project.

5. To adopt appropriate design standards in order to ensure the functions of toll motorway which can provide higher services to the users.

OVERALL PROJECT IMPLEMENTATION SCHEDULE

Route	Items	Duration (Months)	1995	1996	1997	1998	1999	2000	2001	2002
N-Route	Detailed Design	18								
	Land Acquisition	24								
(Lampong-	Bidding	7								
Doi Saket)	Construction	48								
	Openning									
	Annual budget	(%)	1	2	5	14	34	29	15	
	Accumulative Budget	(%)	1	3	8	22	56	85	100	
S-Route	Detailed Design	18								
	Land Acquisition	24								
(Ban Pong-	Bidding	7								
Cha Am)	Construction	36								
	Openning									
	Annual budget	(%)	1	1	3	40	33	22		
	Accumulative Budget	(%)	1	2	5	45	78	100		

1 INTRODUCTION

1.1 BACKGROUND

A nationwide inter-city toll motorway network of 4,300 km (the Network) was proposed in the study titled "The Toll Highway Development Study in the Kingdom of Thailand" (the Master Plan Study) carried out by the Japan International Cooperation Agency (JICA) during the years 1990 and 1991, in order to accelerate well-balanced development of the whole nation and sustain stable growth of the national economy.

The Government of Thailand (GOT) incorporated the construction of the Network in the Seventh National Economic and Social Development Plan and through the Department of Highways (DOH) sought a technical assistance from the Government of Japan (GOJ) for conducting a feasibility study on two high priority routes with a total length of 232 km.

In response to the request of GOT, GOJ desided to conduct the Feasibility Study on the Inter-city Toll Motorway Projects (the Study). JICA, which is the official agency responsible for the implementation of GOJ technical cooperation programs, organized a study team to be engaged in the Study. The JICA Study Team, in close collaboration with the DOH Conterpart Team, commenced work in August 1993 and completed in March 1995.

1.2 OBJECTIVES OF THE STUDY

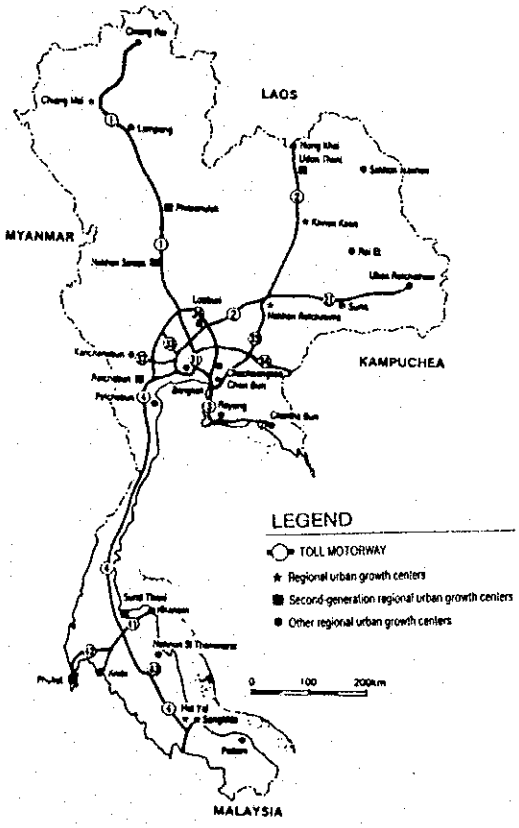
The objectives of the Study are:

1. To formulate an inter-city toll motorway implementation plan for the high priority routes,
2. To propose the methodologies for implementation and operation of the toll motorways, and
3. To perform technology transfer to Thai counterpart personnel in the course of the Study.

1.3 STUDY ROUTES

98.7 km Lampang-Doi Saket Route (L-D Rt.) connects Lampang and Doi Saket traversing three Changwats of Lampang, Lamphun and Chian Mai. A 35-km section of this route at Changwat boundary between Lampang and Lamphun is mountainous section lying on environmental conservation areas. The other sections traverse mostly paddy fields on rolling or flat terrain.

133.7 km Ban Pong-Cha Am Route (B-C Rt.) connects Ban Pong and Cha Am traversing two Changwats of Ratchaburi and Phetchaburi which are well-developed provinces in Thailand. The end of the route, Cha Am is one of the important tourism spots. This route lies mostly on flat paddy fields.



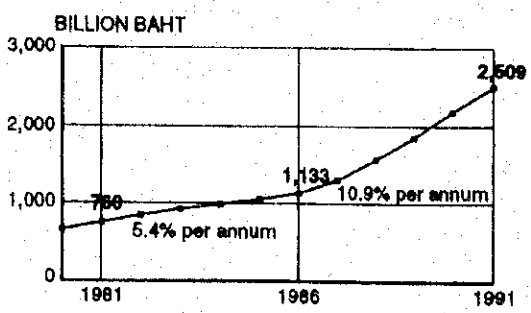
PROPOSED NETWORK

2 SOCIO-ECONOMIC FRAMEWORK

2.1 EXISTING CONDITIONS

Thailand had a total population of 57,789,000 in 1992 with a growth rate of 1.5%. Population growth in Thailand slowed from 2.0% per annum during 1981-1986 to 1.4% per annum during 1986-1991. The population density in 1992 was 112.6 persons per square kilometer (psn/km^2).

In 1991, the Gross Domestic Product (GDP) amounted to 2,509 billion Baht (B.Bt.) at current market prices and to 2,108 B.Bt. at 1988 constant prices. The GDP growth rate of 10.9% per annum during 1986-1991 was higher than the growth rate during 1981 - 1986 of 5.4%. From 1987, Thailand's economy turned up due to an increase in exports and an influx of foreign investment. The percentage share of the agricultural sector decreased from 21.4% in 1981 to 12.8% in 1991, while the manufacturing sector grew steadily and expanded its share from 22.6% in 1981 to 28.2% in 1991. Per capita GDP increased 2.8 times from 15,934 Bt. in 1981 to 44,085 Bt. in 1991.



GDP AT CURRENT MARKET PRICES

1. L-D Rt. (Northern Region)

Population

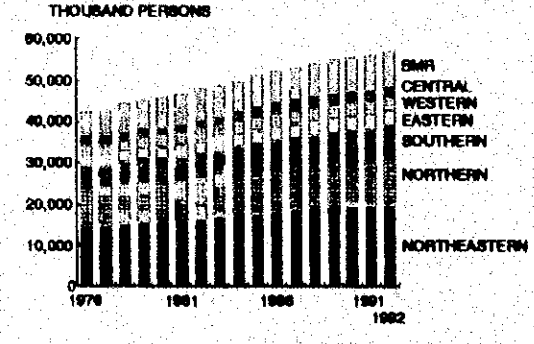
The northern region had a population of 11,683,000 in 1992 and its total share to whole country was 20.0. By Changwats, the population of Chiang Mai, Lampang and Lamphun were 1,531,000, 776,000 and 398,000, respectively.

The population densities were counted 76.1 psn/km^2 in Chiang Mai, 61.9 psn/km^2 in Lampang and 88.3 psn/km^2 in Lamphun, which are lower than that of the national average of 112.6 psn/km^2.

Economic indexes

Gross Regional Product (GRP) in this region accounted for 202,926 million Baht (M.Bt.) at current market prices in 1991 and its share to GDP was 11.4%. Per Capita GRP was 18,833 Bt. The growth rate of GRP during 1986-1989 was 7.7% per annum, which is lower than the national average of 11.6%. Agriculture was the major economic sector in this region and its share was 30.9% of total GRP.

Gross Provincial Product (GPP) in Chiang Mai, Lampang and Lamphun were 33,481 M.Bt., 15,905 M.Bt. and 6,503 M.Bt. with average growth rates during 1986-1989 of 4.8%, 4.1% and 5.2%, respectively. Per Capita GPP in Chiang Mai was 24,727 Bt. which was the highest in this region, followed by 21,039 Bt. of Lampang. As for GPP by sector, Chiang Mai depends more on services than on agriculture. The share of services was 22.6% and the average annual growth rate during 1986-1989 was 9.2%. Lampang depends on mining/quarrying and wholesale/retail trade, which shred 18.8% and 17.6% respectively, while Lamphun depends on agriculture (26.5% share) followed by wholesale/retail trade (19.5% share).



POPULATION BY REGION

2. B-C Rt. (Western Region)

Population

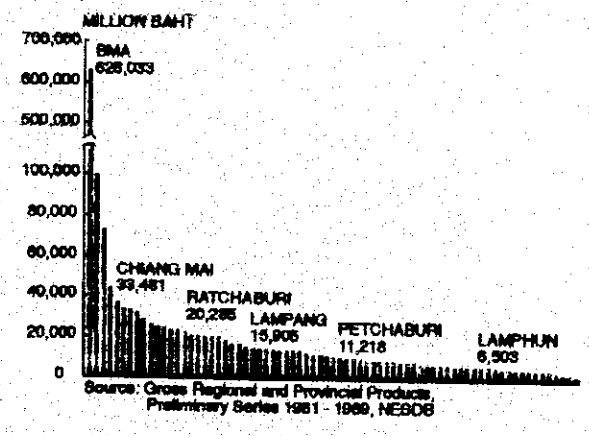
The western region had a population of 3,424,000 in 1992 and its share to whole country was 5.9%. By Changwats, the population of Ratchaburi and Phechaburi were 777,000 an 439,000, respectively.

The population densities were counted 70.5 psn/km^2 and 149.5 psn/km^2, while national average was 112.6psn/km^2.

Economic indexes

GRP in this region accounted for 92,183 M.Bt. at current market prices in1991 and its share to GDP was 5.2%. Per Capita GRP was 28,434 Bt. The growth rate of GRP during 1986-1989 was 8.7% per annum, which is lower than the national average of 11.6%. Agriculture was the major economic sector and its share was 26.1% of total GRP.

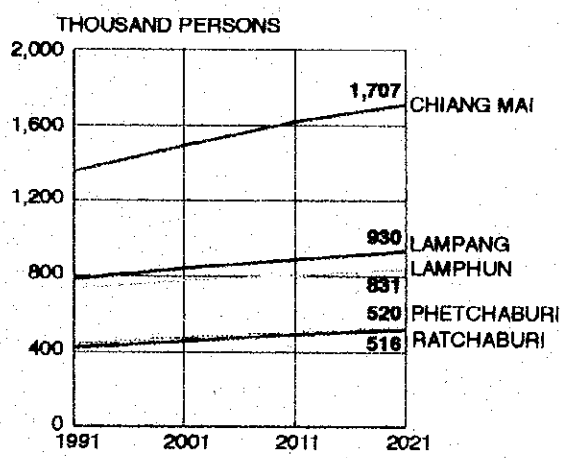
GPP in Ratchaburi and Phetchaburi were 20,285 M.Bt. and 11,218 M.Bt. with average annual growth rates during 1986-1989 of 4.2% and 5.0%, respectively. Per Capita GPP in Ratchaburi was 28,733 Bt. followed by 26,709 Bt. of Phechaburi, which are lower than Per Capita GDP of 32,028 Bt. As for GPP by sector, the share of manufacturing in Ratchaburi was 23.0% followed by agriculture (18.1%) and wholesale/retail trade (16.2%). In Phetchaburi, wholesale/retail trade shared for 21.7% followed by 17.3% of agriculture.



GPP IN 1989

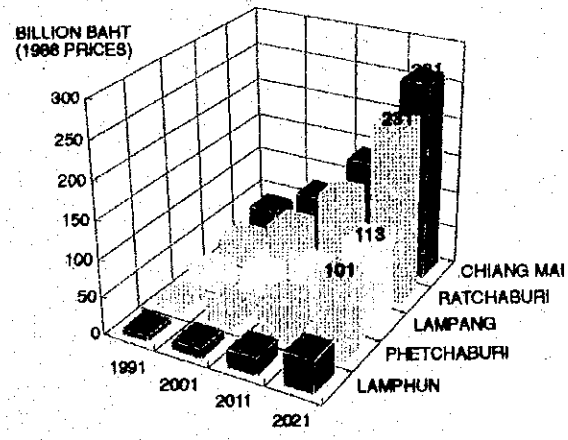
2.2 FUTURE FRAMEWORK

Future populations in Amphoes are estimated by Changwats' future populations as the control total which are projected on the basis of past trends and "The Population Projection for Thailand, 1980-2015" prepared by a working group of NESDB. The Changwat's populations in 2021, Chiang Mai, Lampang, Lamphun Phetchaburi and Ratchaburi, will be 1.7 million (M.), 0.93 M., 0.83 M., 0.52 M. and 5.2 M., respectively.



POPULATION PROJECTION

NESDB provides the data on GRP growth rates during 1991-2011 and regional share of GDP in 1991. The future GRP up to 2021, the control total for GPP projection, is estimated by these data. GPP projection gives Changwats' products 1n 2021 as 261 B.Bt. of Chiang Mai, 231 B.Bt. of Ratchaburi, 113 B.Bt. of Lampang, 101 B.Bt. of Phetchaburi and 43 B.Bt. of Lamphun.



GPP PROJECTION

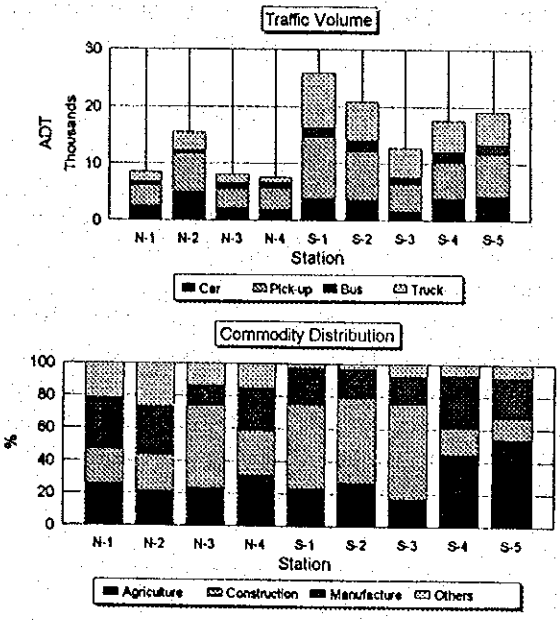
3 TRAFFIC DEMAND FORECAST

3.1 METHODOLOGY

In order to investigate the characteristics of the present trip pattern in the area influenced by the two study routes and to forecast the future traffic demand on the routes and national highway network in the area, required traffic information are collected through the three traffic surveys; origin/destination, traffic count and speed surveys. Present OD tables are established first on sub-zonal basis and future OD tables are obtained applying a trip generation model to major parameters of the future socioeconomic framework. Induced trips are also estimated and the combined OD tables are assigned on the road network for the two cases of "without project" and "with project" to estimate the future traffic volumes on the two motorways and national highway network.

3.2 PRESENT TRAFFIC

Traffic survey stations in the southern area [S-1 to S-5] recorded ADT between 15,000 and 25,000 vehicles with higher shares in commodity vehicles and buses than the stations in the north [N-1 to N-4] which have ADT between 7,000 and 15,000 vehicles. Commodity distribution shows high share of construction materials at stations near BMR. Night traffic is about 29% around the southern route and 22% in the north. The average speed measured on the national highways is ranging between 70 and 90 km/hr.



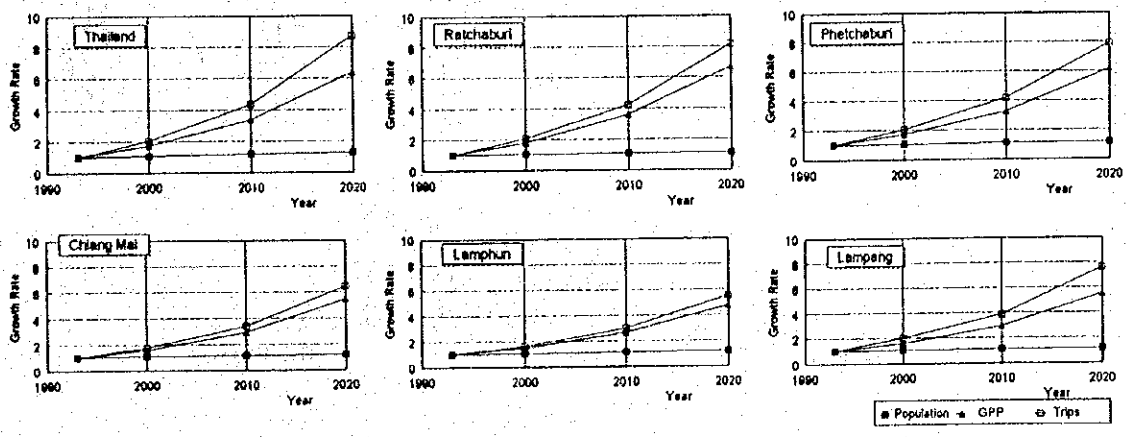
LOADING CHARACTERISTICS

Passenger Vehicles:		PC	PU	LB	HB
Capacity	N	5.0	12.9	12.1	71.1
	S	5.0	12.6	12.9	61.3
Occupancy	N	2.2	2.7	6.9	51.5
	S	2.3	2.8	4.7	32.0

Commodity Vehicles:		PU	LT	MT	HT
Capacity [ton]	N	1.50	3.12	7.62	11.3
	S	1.31	3,41	6.86	11.3
Payload [ton]	N	0.88	0.98	3.34	5.88
	S	0.70	1.58	3.29	6.10
Empty %	N	24.8	67.0	47.2	43.8
	S	26.8	34.6	39.9	38.9
Assistants	N	0.65	0.73	0.60	0.58
	S	0.54	0.58	0.62	0.44

3.3 FUTURE TRIPS

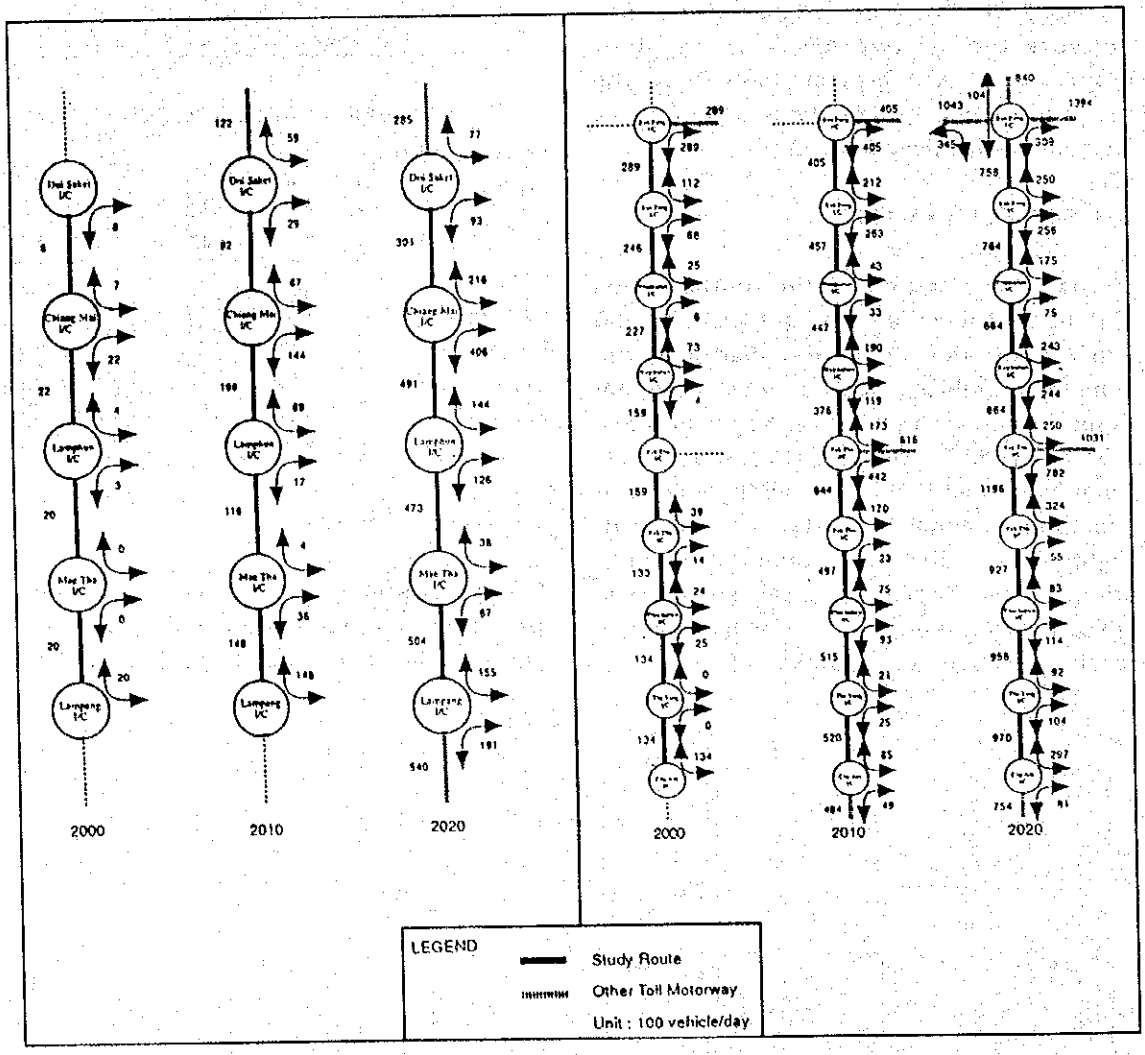
The figures below show the forecasted future growth in the population and gross provincial product [GPP] and the resulted normal



growth in trips for the changwats of the study routes. High growth in trips is forecasted in Lampang, Phetchaburi and Ratchaburi.

3.4 FUTURE TRAFFIC VOLUMES

Traffic demand is forecasted by the assignment of the OD tables, for normal traffic for the case of "without project" and by supplementing the induced trips for the case of "with project". In the "with" case, the future motorway network is assumed to be developed basicaly in accordance with the implementation plan formulated in the Master Plan Study, while in the "without" case, the same network except the motorway section under evaluation is assumed. The presented results below are those obtained by applying the basic toll rate of 1.0 Baht/km while other rates were also investigated for the purpose of the project's financial evaluation. With lower socio-economic growth rates in the changwats of the northern route, future traffic volumes on the route are much lower than the southern route which is close to BMR with high socio-economic growth rates and is expected to have high traffic volumes. The rapid development in the northern region and with neighboring countries, however, is expected to generate additional trips, which are not supplemented in this study, to be loaded on the motorway.



L-D ROUTE B-C ROUTE

4 ROUTE SELECTION

4.1 BASIC POLICY

An optimum route is selected from several alternative routes which are prepared taking into consideration the *control points*, viz., physical, social and environmental constraints. The control points identified are as follows:

1. Natural Condition
   - Mountain range
   - Wide river
   - Soft ground
2. Social Environment
   - Resettlement
   - School and hospital
   - Temple (Wat in Thai)
3. Natural Environment
   - National park
   - Watershed class 1-A and 1-B
   - Wildlife sactuary
   - Forest reserve
4. Public Works and Others
   - City planning areas
   - Special project areas
   - Large-scale housing and industrial estates

Required *number of lanes* for motorways is estimated based on the design traffic volume and the service flow rate (SFR) per lane determined depending on the design level of service (LOS). For route selection purpose, 4-lane for L-D Rt. and 6-lane for B-C Rt. are assumed.

Design requirements on cross-sectional and geometric elements required to secure the mobility as a motorway are discussed and established to prepare the alternative routes.

4.2 PRELIMINARY ROUTE EVALUATION

Five alternative routes for L-D Rt. are prepared as follows:

1. AR-1; Link of A1 and A2
2. AR-2; Link of A1, B1, B5 and B3
3. AR-3; Link of A1, B1, B5 and B4
4. AR-4; Link of A1, B2, B5 and B3
5. AR-5; Link of A1, B2, B5 and B4

A1 and A2 are the links selected in the Master Plan Study, B1 is the link along existing Rt. 11 to make tunnel length shorter, B2 is the link through mountainous area to pass forest reserves with a tunnel, B3 is the link close to city center , B4 is the link through paddy field to avoid urbanized areas, and Link B5 is to connect Mae Tha and Chiang Mai in the shortest distance with two tunnels.

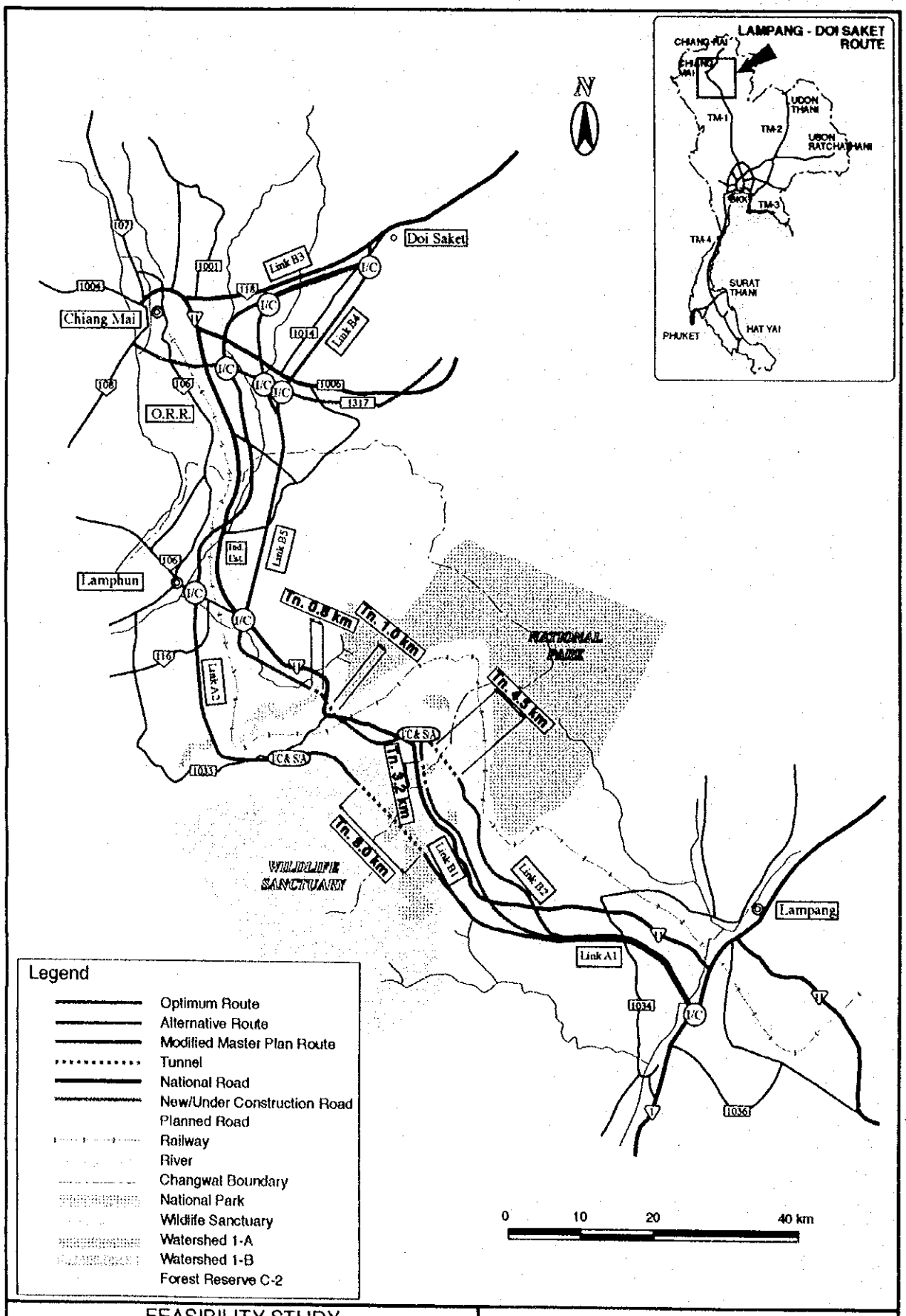
Alternative routes are rated from the socio-economic, environmental, traffic and technical aspects, and as a result, AR-5 is rated as the most appropriate route, followed by AR-3, AR-4 and AR-2, and AR-1. *AR-5 is selected* as an optimum route because it does; i) completely avoid the wildlife sanctuary and the watershed class 1-A, ii) minimize the adverse environmental impacts, iii) avoid city planning areas and highly urbanized areas and iv) avoid the Chiang Mai Outer Ring Road which will be implemented in the near future.

Three alternative routes for B-C Rt. are prepared as follows:

1. AR-1; Link of A1 and A2
2. AR-2; Link of A1, B1 and B2
3. AR-3; Link of A1, B1 and B3

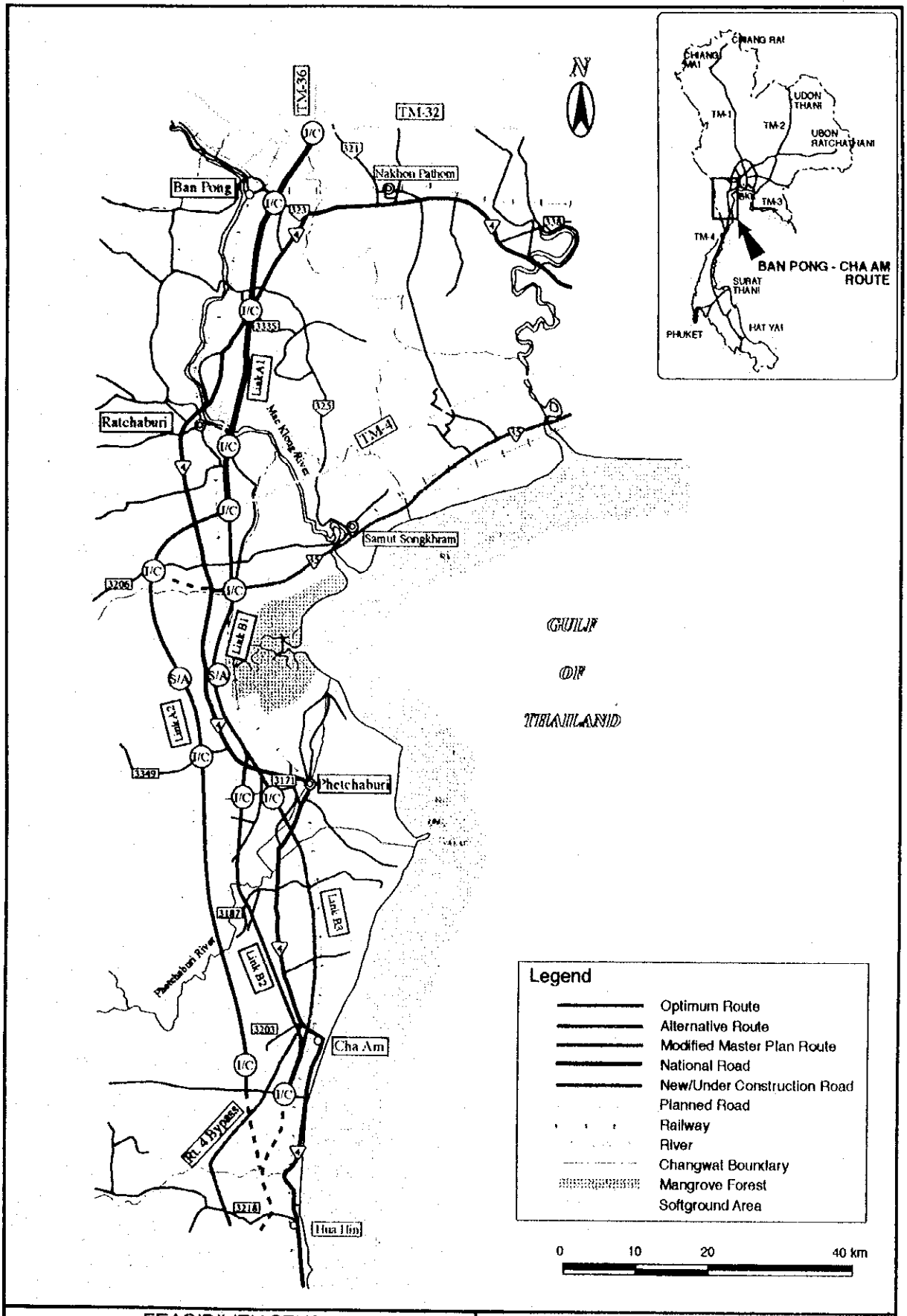
A1 and A2 are the links selected in the Master Plan Study, B1 is the link through paddy field, B2 is the link through suburban and B3 is the link close to the city centers.

AR-2 is evaluated as the best route, followed by AR-3 and AR-1. Therefore, *AR-2 is selected* as an optimum route, while AR-1 has very poor accessibility.



FEASIBILITY STUDY
ON
THE INTER-CITY TOLL MOTORWAY PROJECTS

Alternatives of Lampang - Doi Saket Route



FEASIBILITY STUDY
ON
THE INTER-CITY TOLL MOTORWAY PROJECTS

ALTERNATIVES OF
BNAG PONG - CHA AM

4.3 SELECTED ROUTES

1. L-D Rt.

L-D Rt. generally runs through rural areas in level or mauntainous terrain, connecting three Changwat centers and 13 Amphoes in three Changwats, namely Lampang, Lamphun and Chaing Mai. These Amphoes are classified as urbanized areas, except for Mae Tha which is rural area.

Mobility is as follows: LOS in 2010 will be "A" with a low V/C ratio of o.28 and LOS in 2020 will be "D" with V/C ratio of 0.84 being high density but still stable flow.

As for *accessibility*, 16 of 42 Amphoes in three Changwat will have direct access to interchanges, where residents of 1.46 millions or 54 % among total population of 2.7 millions will be able to arrive at the nearest interchanges with average distance of 16.8 km.

2. B-C Rt.

B-C Rt. traverses two Changwats, Ratchaburi and Phetchaburi, which are are rural level or suburban areas in level terrain. Also the route has a close connection with some Amphoes in four Changwats, namely Kanchanaburi, Nakhon Pathom, Samut Songkhram and Prachup Khirikhan. The route connects four Changwats centers and 18 Amphoes, which are categorized as urbanized area.

Mobility: In the section between Pak Tho junction and Pak Tho interchange, LOS will be "C" in 2010 with V/C ratio of 0.71, being stable flow and in 2020, LOS will be deteriorated to a level of "F", V/C ratio 1.32, forced or breakdown flow. Although 4-lane in 2010 and 6-lane in 2020 in the section between Ban Pong junction and Pak Tho interchange may be acceptable in terms of LOS, 6-lane and 8-lane or second motorway construction will be recommended for the section between Pak Tho junction and Cha Am interchange. In the Study 6-lane is designed whole section of B-C Rt. in considering of the possibility that the second motorway will be proposed after reviewing traffic demand of both motorway and highway network in 2010.

The Study on *accessibility* shows that 23 Amphoe centers in 6 Changwats will be connected with average distance of 21.7 km, covering 2.0 millions or 60 % of total population of 3.3 millions in the 6 Changwats.

ACCESSIBILITY OF MOTORWAY

Population in 1992

Changwat	Whole		Direct Influenced Areas		
	No of Amphoe	Population	No of Amphoe	Population	Distance to Interchange
[L-D Rt.]					
Chiang Mai	22	1,530,900	8	774,100	17.4 km
Lamphun	7	398,000	4	274,100	15.0 km
Lampang	13	776,200	4	413,300	18.0 km
Total	42	2,705,100	16	1,461,500	16.8 km
[B-C Rt.]					
Kanchanaburi	6	724,000	2	229,200	26.0 km
Nakhon Pathom	5	671,000	2	320,400	36.0 km
Samut Songkhram	3	207,000	3	206,500	23.7 km
Ratchaburi	9	777,200	8	728,900	12.7 km
Phetchaburi	8	438,600	7	417,300	14.6 km
Prachup Khirikhan	2	451,000	1	63,600	17.0 km
Total	33	3,268,800	23	1,965,900	21.7 km

5 PRELIMINARY DESIGN

5.1 DESIGN STANDARD

Geometric design standard on main line of motorway should be in higher grade than that of existing highway so that the effective and attractive services to the users can be provided. Design speed of 120 km/h is selected for flat or rolling sections in rural areas and 100 km/h for mountainous section in rural areas and for all sections in urban areas based on the other countries' experiences. Geometric design standards are as follows:

GEOMETRIC DESIGN STANDARD

Description		Design Speed 120 km/h Rural, flat rolling	100km/h Rural, Mountainous and urban
Lane Width	Outer	3.75m	3.75m
	Center	3.75m	3.75m
	Inner	3.75m	3.75m
Median Width		13.50m	13.50m
Shoulder Width	Outer	3.00m	3.00m
	Inner	1.50m	1.50m
Vertical Clearance		5.00m	5.00m
Stopping Sight Distance		290m	210m
		(210)	(160)
Minimum Radius of Curve		1,000m	700m
		(710)	(460)
Maximum Grade		2(4)%	3(5)%
Minimum Radius of Vertical Curve	Crest	21,000m	11,000m
		(11,000)	(6,500)
	Sag	6,000m	4,500m
		(4,000)	(3,000)
Slope of Normal Crown		2.5%	2.5%
Combined Gradient		10.0%	10.0%

( ): minimum or maximum value

Other design standards are established basically based on the DOH Standards.

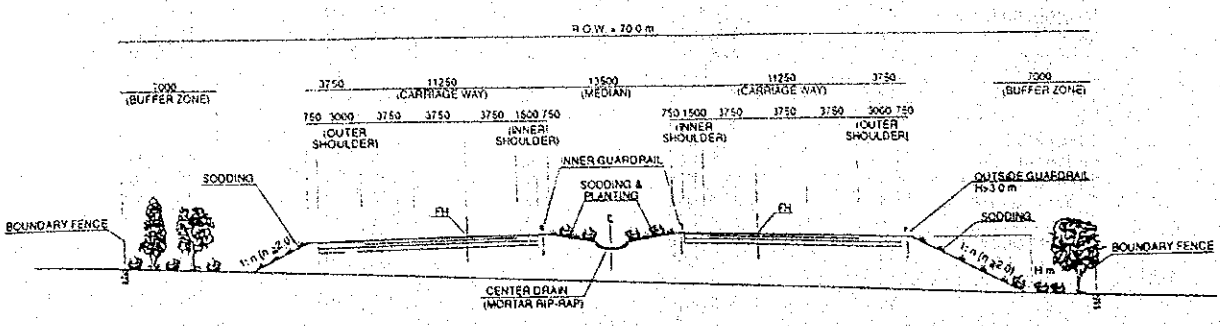
5.2 GEOMETRIC DESIGN

74 % of L-D Rt. and all B-C Rt. have the minimum curve radius of more than 5,000 m, and 75 % for L-D Rt. and 98 % of B-C Rt. have the maximum grade of less than 1 %. These geometric characteristics show that the motorways can provide smoother and safer mobility than the ordinary roads in Thailand.

CHARACTERISTICS OF ALINEMENT

Radius R(m)	5000≤R	4000≤R <5000	3000≤R <4000	2000≤R <3000	1000≤R <2000
Lampang - Doi Saket Route					
Length (km)	73.0	4.8	2.4	9.3	9.2
(%)	74.0	4.9	2.4	9.4	9.3
Ban Pong - Cha Am Route					
Length (km)	133.7	0.0	0.0	0.0	0.0
(%)	100.0	0.0	0.0	0.0	0.0

Gradient i(%)	-5≤i <-4	-4≤i <-3	-3≤i <-2	-2≤i <-1	-1≤i <0	0≤i <1	1≤i <2	2≤i <3
Lampang - Doi Saket Route								
Length (km)	0.8	0.0	10.4	15.0	79.8	67.3	13.0	11.2
(%)	0.4	0.0	5.2	7.6	40.4	34.1	6.6	5.7
Ban Pong - Cha Am Route								
Length (km)	0.0	0.0	0.0	2.7	152.8	109.2	2.7	0.0
(%)	0.0	0.0	0.0	1.0	57.2	40.8	1.6	0.0



Note: In case of 4-lane 2-way, a carriage way length is 7.5 m with same widths shoulders and median.

TYPICAL CROSS SECTION (6-LANE 2-WAY)

5.3 STRUCTURAL DESIGN

Bridges are designed where the main line of motorway crosses over the rivers, large cannels with side-path, railways and the national highways with number of one or two figure(s). RC beam, PC I-section beam and PC box girder bridges are selected depending on span length.

Overbridges are designed where side-path of small cannels, the provincial roads, the sanitary roads and the national highways with number of three or four figures cross over the main line of motorway. A large number of overbridges are designed for avoiding severance of local communication from the environmental aspects.

Viaducts are designed in urban areas and tunnel approach sections over deep valley, where needed due to environmental consideration. For the viaduct on tunnel approach sections, steel truss and concrete box girder are compared and the former is selected mainly because of better constructability. Noise fence is installed on viaduct running through the urban areas.

A large number of *culverts* are designed as the drainage facilities and for avoiding severance of local communication.

LENGTH OF STRUCTURES

Structure	Total	RC beam	PC I-beam	PC Box girder	Steel Truss
[L-D Rt.]					
Bridge	2,091 (31)	366	825	900	0
Viaduct	9,925 (30)	5	3,945	2,450	3,525
Overbridge	3,000 (25)				
Box-culvert	288 (8)				
[B-C Rt.]					
Bridge	4,149 (73)	580	3,209	360	0
Viaduct	11,400 (8)	0	10,520	880	0
Overbridge	7,140 (42)				
Box-culvert	440 (11)				

Note: 1. Unit; m
2. Figures in ( ) are number of structures.

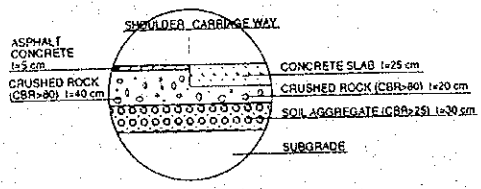
5.4 EARTH WORK AND PAVEMENT DESIGN

The slopes of embankment and cut structure are 1:2 and 1:1 respectively. Surface of embankment slopes are protected by sodding or concrete block masonry from erosion, and cut slopes by structures such as frame with sack or leaning type retaining wall.

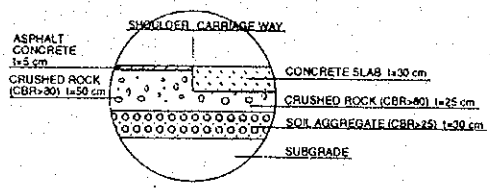
The appropriate compaction and/or soil improvement work to obtain more than 4.0 in CBR of subgrade is required in all earth work sections to provide a stable subgrade for pavement.

Cement stabilization with 2 m depth is introduced in the soft ground section of B-C Rt. in order to prevent irregular settlement in future. Bearing unit is designed just behind an abutment to minimize a gap between embankment and structure.

Concrete pavement is adopted on all sections of both L-D Rt. and B-C Rt. mainly because of availability of material.



L-D Rt.



B-C Rt.

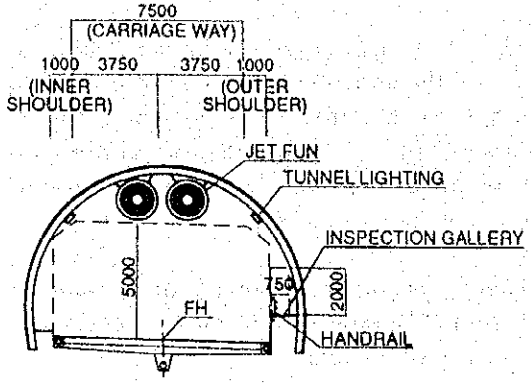
PAVEMENT SECTION

5.5 TUNNEL

Two tunnels, with lengths of 3,800 m and 750 m, are designed along the mountainous sections of L-D Rt. to avoid passing on the surface of environmental conservation areas.

The cross section of the tunnel is designed to be sufficient to comply with the clearance requirement. The widths of both shoulders are

decreased to 1.0 m to minimize contruction costs and to discourage vehicles stopping in the tunnel. In addition to the roadway and shoulders the internal space has to be sufficient to accommodate ventilation facilities, lighting fixtures, fire prevention services, interior finish and management facilities. The tunnel structure has to be designed to resist external loads such as earth and water pressure.



TUNNEL CROSS SECTION

The New Austrian Tunneling Method (NATM) is a construction technique that takes advantage of the inherent strength of the natural ground enhanced by the use of rock bolts and shotcrete. It is proposed to use the NATM for both of the proposed tunnels on L-D Rt. as it offers significant advantages over conventional techniques. These are: 1) reduced construction time, 2) enhanced work safety, 3) reduced labor requirement and 4) reduced construction cost.

A tunnel portal can be considered as a sort of retaining wall and is thus subject to the same design and construction methods. In consideration of the environmental requirements and economy of construction, the portal types selected for the two tunnels are wing wall types and outstanding types.

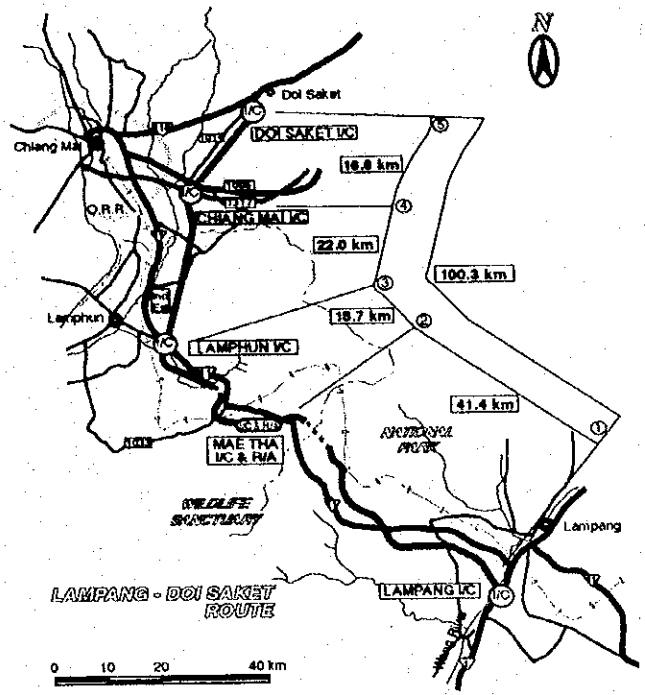
The primary functions of *the ventilation system* is to remove noxious and toxic exhaust fumes and to enhance visibility by removing suspended particulate matter in the tunnel atmosphere. With due consideration of the economic constraints and air quality standards, the recommended system of ventilation for 3,800 m tunnel is the combination of Jet Fans with electric dust collector. As for 750 m tunnel, the natural flow of air will be sufficient in normal circumstances but it is proposed that two jet fan units be installed for emergency use.

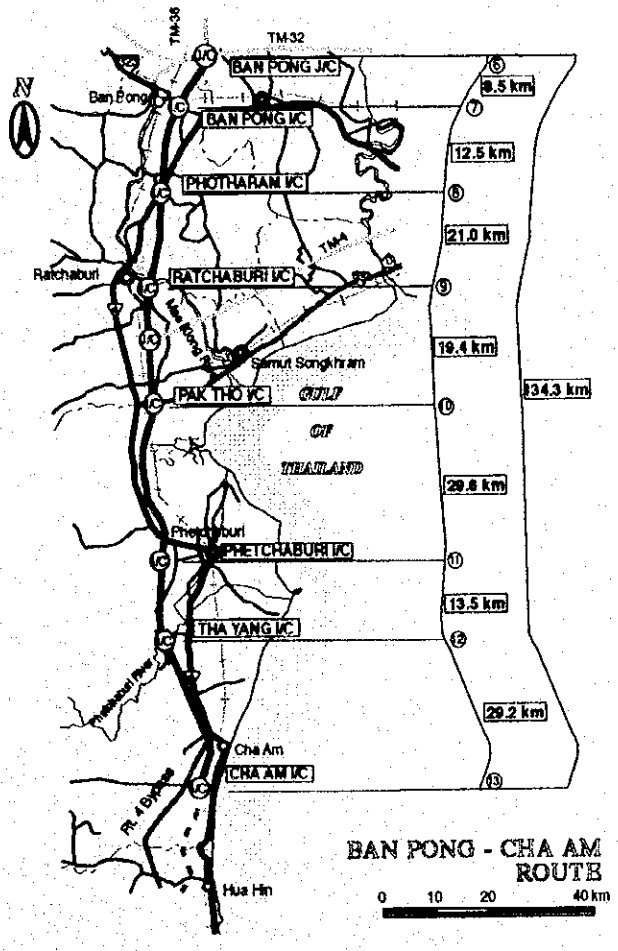
5.6 DESIGN OF INTERCHANGE AND SERVICE FACILITIES

The locations of interchanges shall be at strategic points in a present and future road network, such as suburbs of major cities, sightseeing spots, industrial areas, intersecting points with main highways, etc., where a large traffic is expected to be generated and attracted. Designed in the Study are 5 interchanges on L-D Rt., and 8 interchanges including 1 junctions on B-C Rt.

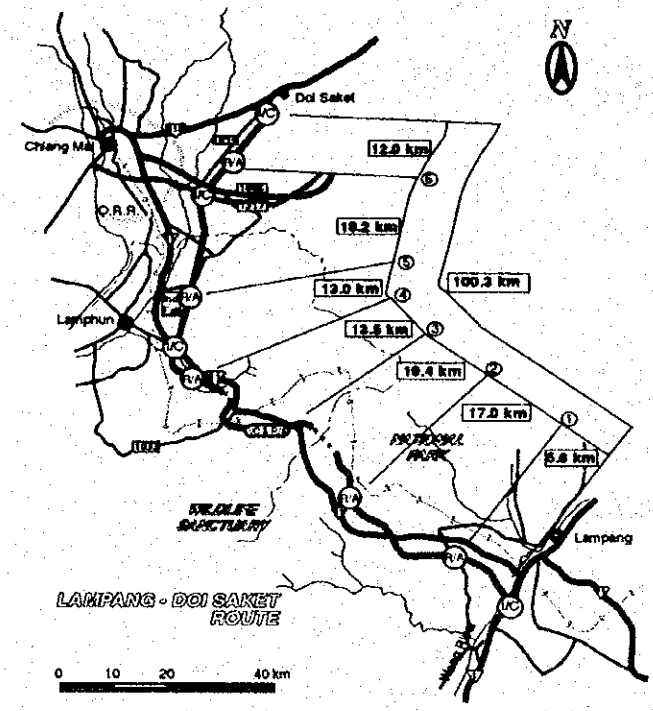
As for *type of interchange*, trumpet-type is generally used to concentrate all on- and off-toll gate. Semi direct connection type such as Y-type also is adoptable especially at hilly or mountainous terrain. The study proposes 6 double-trumpet interchanges, 6 single-trumpet interchanges and 1 turbine-type junction.

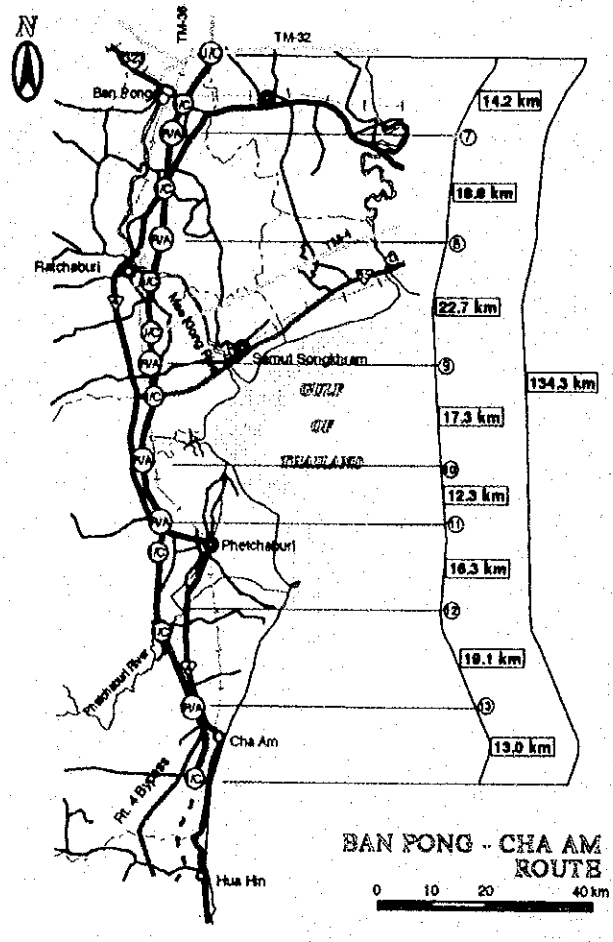
The function of *service area* is to provide all services including parking lots, toilet, restaurant, kiosk, service station, etc., 13 rest areas (6 for L-D Rt. and 7 for B-C Rt.) and 18 bus stops (8 for L-D Rt. and 10 for B-C Rt.) are proposed in the Study.



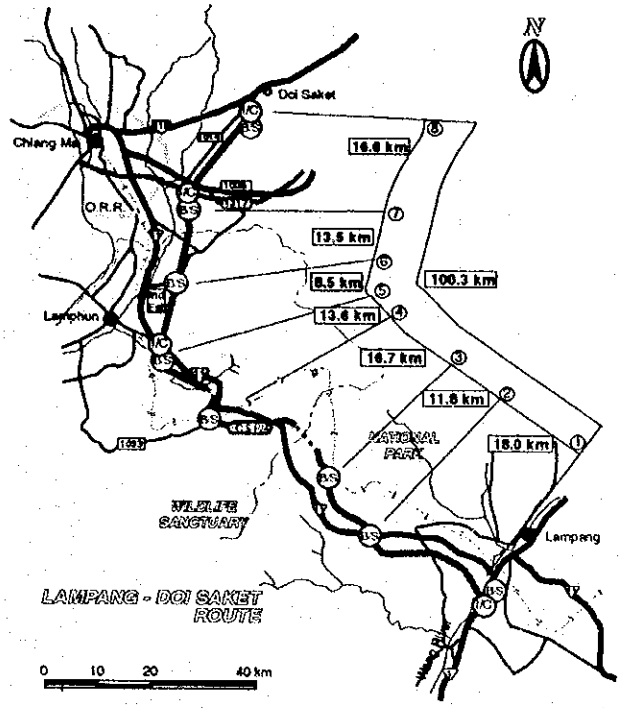


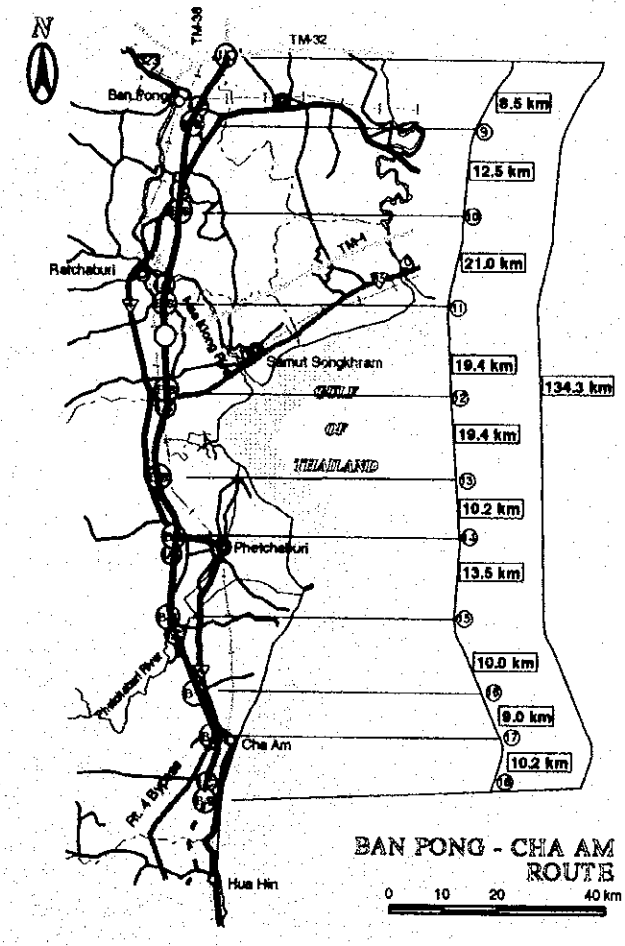
FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	LOCATION OF INTERCHANGES





FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	LOCATION OF REST AREAS





FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	LOCATION OF BUS STOPS

6 ENVIRONMENTAL EXAMINATION

6.1 LAW AND AGENCY

In *the Environmental Act* (the Act) revised in 1992, unprecedented authority has been given to three department level environmental management agencies, i.e., the Office of Environmental Policy and Planning (OEPP), the Department of Pollution Control (DPC) and the Department of Environmental Quality Promotion (DEQP); all of which are entrusted by a newly-setup ministerial level organization, the National Environment Board (NEB).

To declaring the environmentally protected areas, the Act requires *the Environmental Impact Assessment (EIA)* for specific size and type of projects; a large scale road construction is fallen into this category. An EIA report should be prepared by registered consultants, and prepared report is reviewed by the EIA division of OEPP and must have a final approval from the NEB. The report should include the analysis of potential adverse impacts on the environment and also propose mitigation measures.

The supervising ministry-level bodies to manage natural resource conservation are the Ministry of Agriculture and Cooperatives (MOAC) and Ministry of Science, Technology and Environment (MOSTE). Under MOAC, the Department of Forestry exclusively controls matters by using Natural Park Division and the Wildlife Sanctuary Division as major control agencies. Under MOSTE, the Environmental and Natural Resources Coordination Division and the EIA Division under the OEPP act as major division-level controlling bodies to supervise natural resources conservation.

6.2 ENVIRONMENTAL EXAMINATION

The assessment of environmental impacts caused by the project implementation including monitoring existing conditions and modeling is presented on 10 items; air quality, noise, vibration, water resources and aquatic ecology, soil conditions, terrestrial ecology, transportation network, land use pattern, socio-economic conditions and cultural/aesthetic/archaeological values.

Appropriate mitigation measures to alleviate negative impacts of the project implementation on 10 items above are concerned, based on the planned preliminary design.

1. During construction stage, mitigation measures to be taken are as follows:

Air quality
Water and chemical sprinkling, setting silos, shrouding the aperture for dry mix batching and confining working vehicles, in construction sites and stock yards are efficient means.

Noise and vibration
Low noise and vibration construction equipment and methods are recommended in the areas relatively close to the receptors.

Soil erosion
Major earthwork in concerned areas should be avoided during heavy rainy season.

2. The effective mitigation measures for negative impacts during operation stage, to be considered in design, are as follows:

Air quality
An appropriate ventilation system is designed in two tunnels of L-D Rt to keep the pollutant concentration at an acceptable level.

Noise
Noise barriers on viaduct sections and buffer zone and earth berm on embankment or cut sections designed in the Study are effective for deducting noise by 2 to 12 dBA.

Water resources/aquatic ecology
For preventing water contamination, effectively maintaining designed drainage system results to prevent pollutants runoff from the road surface, and properly designed facilities to treat waste water discharged from rest areas are installed in the Study.

Soil erosion
Various slope protection works including sodding and seeding, retaining wall, masonry surfacing, etc. and proper drainage systems are proposed on in the Study.

Soil conditions

Embedding cement stabilization into soft top soils, installing bearing unit system in areas with high embankment of bridge approach section and gradual embankment work with monitoring soil behavior during construction are applied at soft ground areas on B-C Rt.

Transportation network

To maintain inter-community traffic and access between farmers and their fields, mitigation measures on constructing frontage roads connected by overbridges or box-culverts are taken in the Study.

Land-use pattern

Particular attention should be made for newly development industrial estates, which will be potential sources of environmental digression, regarding air quality from excessive industrial emission and water quality from improperly-treated effluent discharges.

Socio-economic conditions

Viable mitigation measures to minimize negative induced socio-economic impacts include the control on changes in land use. To prevent unfavorable land value hike, new commercial and industrial development in likely affected areas must be strictly controlled. Relevant agencies prepare appropriate land use planning in line with the motorway management Program.

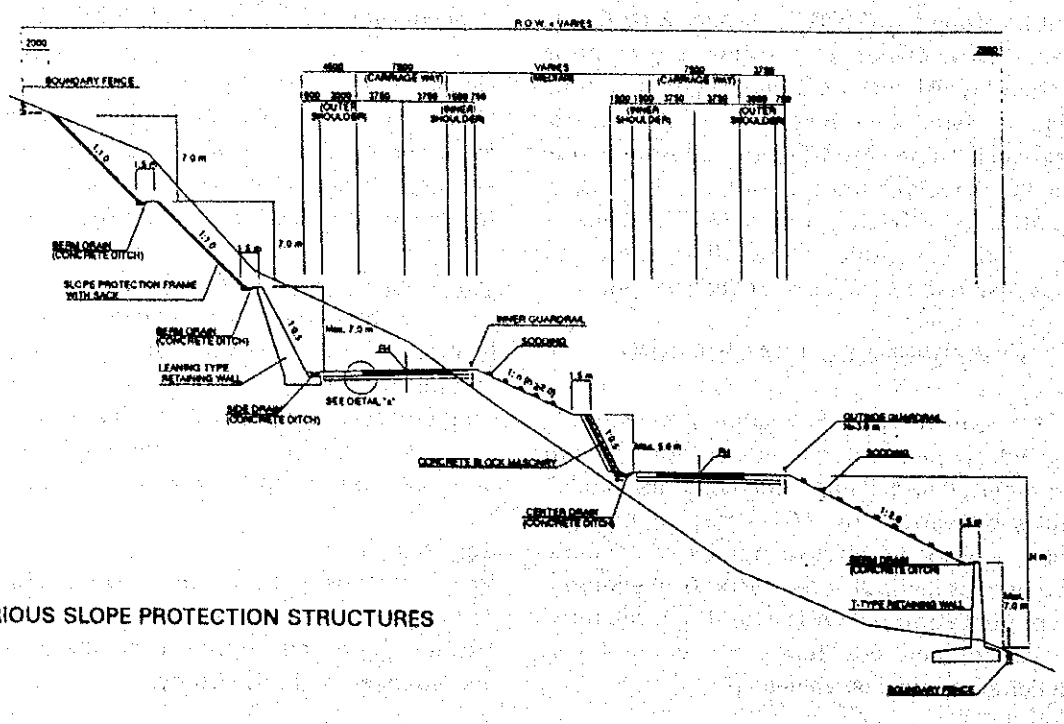
Human relocation

If measures on human relocation problems are not viable, appropriate compensation measures should be taken place; the measures should include provision of sufficient fund or substitution housing in proper locations to keep at least same level of living standards for relocated inhabitants. Resettlement plans should be prepared in order to ready at the time of appraisal.

Aesthetic/archaeological values

To mitigate visual impairment on harmony in areas of temples nearby, bridge construction areas, mountainous areas, etc., tree planting, sodding, seeding, artistic efforts including coloring are planed to create or improve their attractiveness in the Study.

It is recommended that a public hearing should be held at proper timing. The hearing is desired to be organized by relevant agencies and to be based on integrity and goodwill. The purpose of the hearing is to solve conflicts between an executing agency and inhabitants. Hence, the hearing has to provide a whole picture of the projects, both pros and cons, with inhabitants, and the agency acquires better understand of inhabitants' concern.



VARIOUS SLOPE PROTECTION STRUCTURES

7 MANAGEMENT AND OPERATION SYSTEM

7.1 MANAGEMENT SYSTEM

The Study emphasizes the need to establish a new state enterprise, tentatively named as the Inter-City Motorway Authority (ICMA), in order to execute the construction, maintenance and operation activities of the motorway system, for following reasons:

1. Implementing the huge project of the Inter-City Toll Motorway system should be regarded as a national project for the future development and prosperity.

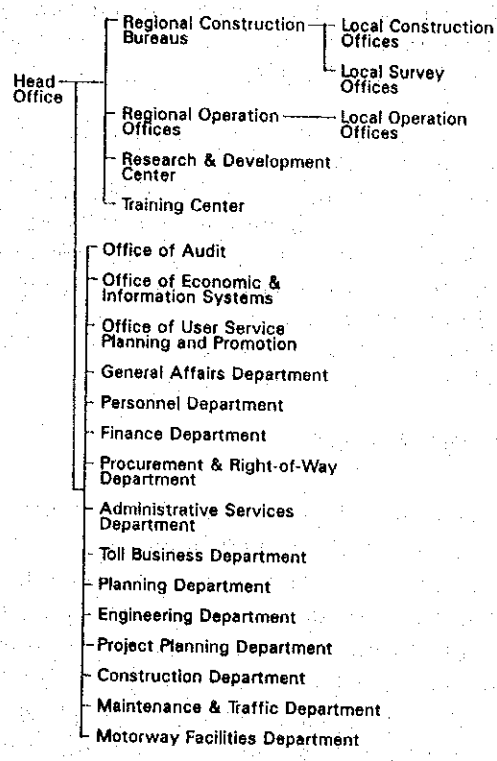
2. The new state enterprise will have the maneuverability, flexibility and quick response required to promote the activities of the motorway network project.

3. The trustworthiness in a state enterprise is an important factor to acquire the required investment funds from various sources such as the international financial institutions as well as the private sector.

4. The new enterprise will have the ease of reinforcing the project's management process and introducing a pool payment system to expand the motorway network, as well as providing uniform services.

Almost all the countries having inter-city toll motorway systems are establishing the state enterprises. The ICMA is to be under the supervision of the Ministry of Transport and Communications (MOTC) with the specific objectives of financing, constructing and operating the 4,300 km network. The ICMA is expected to be guided by concerned ministries and agencies such as DOH, Ministry of Finance, National Economic and Social Development Board (NESDB), etc.

To develop policy and strategy and to study legal, economic and engineering issues, it is urgently required to establish first a motorway organizing committee with the secretariat office at the DOH. For actual implementation, the existing Office of Toll Highway of the DOH should be immediately restructured to cope with the required roles and functions.



ICMA ORGANIZATION

7.2 FUNDS FOR IMPLEMENTATION

There are generally various sources of funds for implementing the inter-city toll motorway system. Among these sources, the Study recommends: 1. government investment, or 2. soft loans for government subsidy.

1. Public Investment: The funds by earmarked tax revenues are based on the beneficiaries pay principle. Specific taxes such as gasoline tax, oil tax, vehicle acquisition and ownership taxes, etc. should be introduced in similar systems as adopted in many countries. However, considering the huge budget required to implement the motorway network, it is inevitable for the government implementation agencies to raise the funds of the foreign portion by means of low-interest-rate loans from international institutions, such as the Overseas Economic Cooperation Fund of Japan (OECF), World Bank, Asia Development Bank (ADB), etc., and to include the required local portion into the national budget.

2. Government Subsidy: Soft loans as the official development assistance (ODA) can

be expected from international financial institutions, apart from the sources of general taxes. These loans from multilateral or bilateral resources may be converted into a corporate equity.

3. Private Financing: A whole package of financial arrangements can be available ranging from the financing by the government to the funds entirely financed by the private sector. The typical practice where private sector is presently being participated in highway or expressway projects is the Build-Operate-Transfer (BOT) or BT scheme.

7.3 TOLL SYSTEM

Because the 4,300 km inter-city toll motorway network is connecting all the regions and major cities and linking all the main routes depending on the origin and destination of the vehicular trips, the applicable toll system should be the closed system based on the toll rate according to the distance traveled with the terminal charge being added for each motorway user as a fee for usage of interchange facilities.

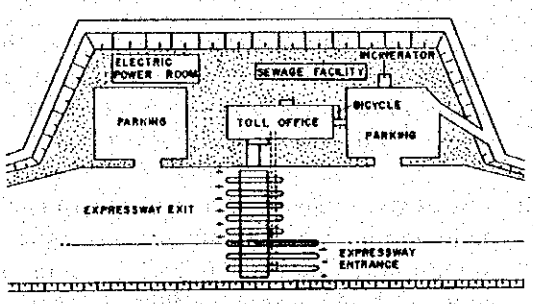
Each section or route of the motorways should constitute a complete network system by linking to each other, therefore, the pool system is reasonable and adequate to maintain uniformity, consistency and equality of the toll system. Differences in the toll rates should be avoided within the network attributable to differences in the implementation time schedule and traffic volume, or to execute scheduled installment of loan repayment.

The Study recommends that the widely-used magnetic card type collection system in consideration of the practicability and easiness of system control. Magnetic card type collection system outlines; that the user receives a transit ticket, and hands out the ticket at the exit toll gate paying the toll automatically calculated by the system machines. Vehicles are automatically preclassified by a classification unit and the operator at the toll gate also classifies manually the vehicle type. The recommendable typical vehicle classification is as follow:

VEHICLE CLASSIFICATION FOR TOLL RATES

Class	Definition	Rate Weight
A.	Passenger Car, Taxi, Pick-up, Micro-bus or Vehicles having 2 axles and 3 or 4 wheels	1.0-1.2
B.	Truck and Mini-bus of less than 8 tons or Vehicles having 2 axles and 5 or 6 wheels	1.2-1.5
C.	Heavy Truck and Bus of more than 8 tons Vehicles having 3 or more axles	1.5-2.0
D.	Extra Heavy Truck, Large Bus, Trailer or Vehicles having 4 or more axles	2.0-2.5

Usually each toll office has an average plotted area of 3,000 to 5,000 m^2 varying by scale and geographical conditions.



LAYOUT PLAN OF TOLL OFFICE

7.4 MAINTENANCE PLAN

Operational responsibility on motorway maintenance should belong to division offices through district offices. Organizational structure at division level of the whole network can be divided into 11 divisions as per their respective coverage of 250 km to 600 km, and the total number of district offices is estimated to be approximately 90 offices.

In order to accomplish the objectives of the maintenance, works which should be carried out are; i) inspection including daily, periodic and extra inspection activities, ii) road cleaning for road surface, incidental facilities, roadside facilities and road fixture, iii) vegetation control for all vegetation materials to play their intended roles, and iv) repairs on all motorway structures and facilities.

It is important to formulate a maintenance work plan because many of the works are carried out on the road shoulders or by restricting one lane by application of traffic

regulations disseminating work information in advance. It would be recommendable for the head office to work out and prepare a maintenance manual covering all procedures from planning to reporting on road inventory.

7.5 TRAFFIC CONTROL

The basic functions of traffic control are to ensure smooth traffic flow and safety, and to provide the users with comfort. The main tasks of traffic control can be divided into four items; planning and programming, traffic engineering, traffic operation and coordination with related agencies including publics.

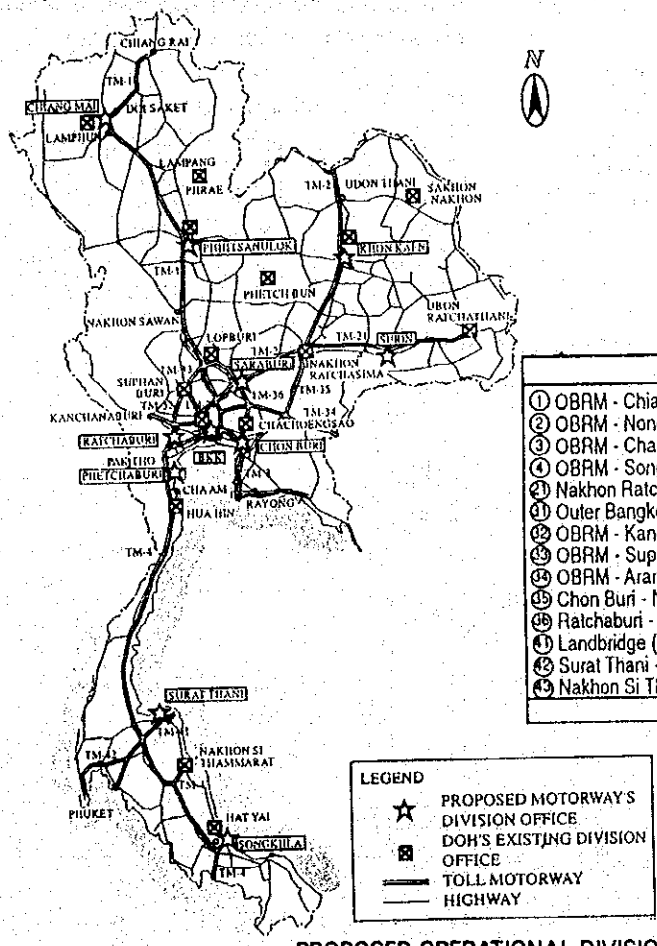
The head office is responsible for planning, development and formulation of standards. The division office is responsible for traffic engineering studies to enhance the efficiency and quality of traffic operations. The district office carries out the field activities of traffic control and operations such as patrolling, inspections and accident investigations through coordinating with the traffic police if necessary.

The traffic control system has four major functions, information collection, information processing and decision making, information dissemination and execution and enforcement of the decision.

7.6 TRAFFIC SAFETY

Measures to handle traffic accidents comprise preventive measures against occurrence of the accident itself and countermeasures to minimize the casualties of road users by applying improvements for driving conditions, enhancement of safety and optimization of driving environment. The major safety facilities include the road lighting, tunnel safety facilities including ventilation and lighting, meteorological information facilities, measuring instruments and road drainage.

Since the long-distance inter-city motorways are newly introduced into Thailand, it is recommended to prepare and conduct a traffic safety campaign and guidance for the introduction, development and improvement of traffic safety and safety driving.



Route	Length (km)
① OBRM - Chiang Rai	755.6
② OBRM - Nong Khai	535.5
③ OBRM - Chanthaburi	291.9
④ OBRM - Songkhla	951.4
㉑ Nakhon Ratchasima - Ubon Ratchathani	301.1
㉛ Outer Bangkok Ring Motorway(OBRM)	167.7
㉜ OBRM - Kanchanaburi	100.0
㉝ OBRM - Suphan Buri	62.0
㉞ OBRM - Aranyaprathet	211.7
㉟ Chon Buri - Nakhon Ratchasima	239.1
㊱ Ratchaburi - Chachoengsao	365.8
㊶ Landbridge (Krabi - Khanom)	190.7
㊷ Surat Thani - Phuket	136.0
㊸ Nakhon Si Thammarat	36.9
Total	4,345.4

PROPOSED OPERATIONAL DIVISION OFFICES

8. COST ESTIMATES

8.1 GENERAL

The basis component of the project cost includes construction cost, physical contingency, maintenance and operation costs, land acquisition cost and engineering and supervision costs.

The basic assumptions and condition for cost estimate are as follows:

- November, 1994 prices
- US$1.0 = 98.18 Yen = 25.01 Baht
- Foreign currency component;
  - Imported equipment, materials, supplies
  - Imported materials in the local market
  - Wages of expatriate personnel

  Local currency component;
  - Domestic materials, supplies
  - Wages of local personnel
  - Tax.
- Land acquisition cost from Land Acquisition Division of DOH.
- Contingency; 10 % of construction cost
- Engineering service;
  - for L-D Rt., 6 % of construction cost
  - for B-C Rt., 4 % of construction cost
- Embankment material;
  - from cut sections
  - from borrow areas with 20 km distance

8.2 UNIT COST ANALYSIS

Major material costs are derived from DOH, and the costs of major equipment including hiring and operation are surveyed. Both costs are divided into foreign and local currency portions based on general condition. The unit cost of each work item is composed of labor cost, material cost, hiring and operation costs of equipment and contractor's overhead and profit. The unit costs also are calculated dividing into foreign and local currency portions.

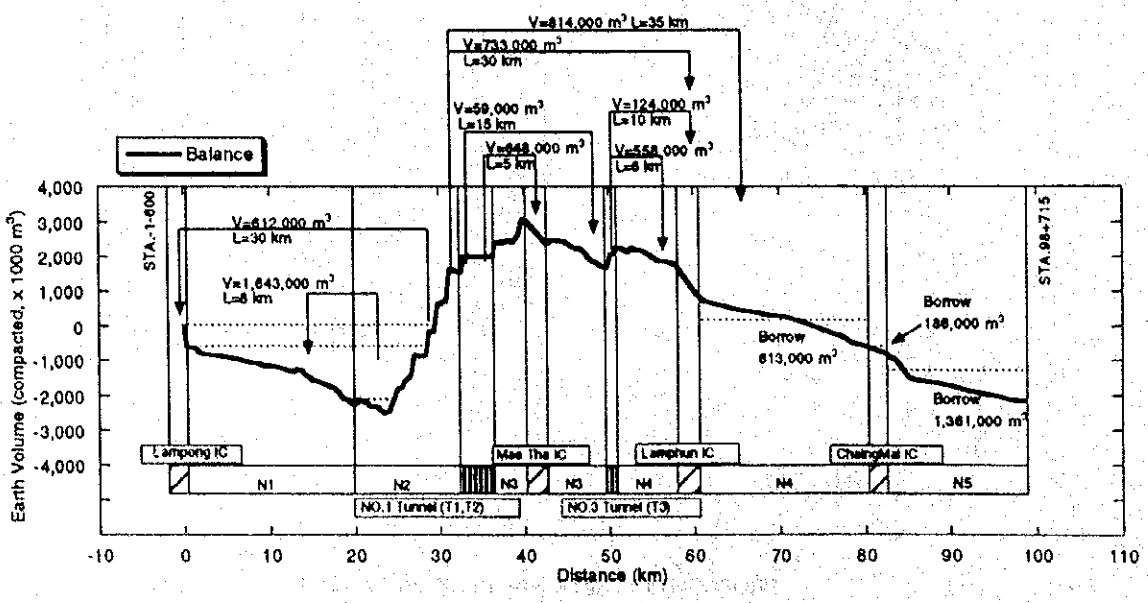
8.3 CONSTRUCTION QUANTITIES

12 and 15 contract packages for L-D Rt. and B-C Rt. respectively are assumed in connection with construction planning. Excavated material in mountainous sections of L-D Rt. must be hauled and used in embankment sections. Mass haul curve shows that an average hauling distance between excavation and embankment sections is 20 km.

MAJOR QUANTITIES

Work item	Unit	L-D Route	B-C Route	Total
Foundation Improvement Works	sqm	0	3,545,000	3,545,000
Roadway Excavation	cum	8,534,000	0	8,534,000
Embankment	cum	10,045,000	9,180,000	19,225,000
Pavement	sqm	1,945,000	4,148,000	6,093,000
Bridge Works	sq/m	64/14,456	81/15,549	145/30,005
Tunnel Works	m	9,110	0	9,110
Land Acquisition	sqm	6,987,000	11,453,000	18,440,000

MASS HAUL CURVE OF L-D RT.



8.4 PROJECT COST

The project cost is summed by construction cost, maintenance and operation costs, land acquisition cost and engineering and supervision costs

The construction cost is estimated by using the construction quantities of each package and unit cost of each work item.

The maintenance and operation cost, which is initial investment for system installation, is estimated by using the data collected from Japan, Malaysia, and ETA. Referencing the case of Japan's initial construction stage of motorways, 2 % of construction cost is applied for maintenance and operation cost.

SUMMARY OF PROJECT COST

L-D Rt.

No.	Contract Package	Length (m)	D.Const. Cost (1000 Baht)	Cost per KM. (1000 Baht/KM.)	Land Acq. (1000 Baht)	Project Cost (1000 Baht)
1	Lampong IC	1,900	321,929	169,000	74,516	422,200
2	Package N1	19,700	1,740,065	88,000	106,997	1,986,267
3	Package N2	12,400	4,861,889	392,000	49,724	5,300,564
4	Package T1	4,100	1,880,347	459,000	943	2,031,718
5	Package T2	4,100	1,880,347	459,000	943	2,031,718
6	Package N3	10,700	4,236,184	396,000	40,011	4,615,090
7	Maetha IC	2,400	1,894,064	789,000	34,819	2,080,408
8	Package T3	2,340	941,131	402,000	3,272	1,019,694
9	Package N4	26,630	3,572,055	133,000	194,628	4,052,447
10	Lamphun IC	2,600	1,170,876	450,000	72,937	1,337,484
11	Changmai IC	2,300	610,047	265,000	312,375	971,226
12	Package N5	16,214	912,095	56,000	729,654	1,714,717
	Total	105,584	24,021,029	228,000	1,620,819	27,563,533

B-C Rt.

No.	Contract Package	Length (m)	D.Const. Cost (1000 Baht)	Cost per KM. (1000 Baht/KM.)	Land Acq. (1000 Baht)	Project Cost (1000 Baht)
1	Banpong JC	1,900	1,172,943	617,000	28,985	1,271,985
2	Package S1	14,850	2,193,227	148,000	62,370	2,387,191
3	Banpong IC	2,650	2,195,899	829,000	151,800	2,479,453
4	Potharam IC	3,100	2,544,000	821,000	101,100	2,797,740
5	Package S2	17,100	2,012,812	118,000	59,850	2,193,430
6	Ratchaburi IC	2,700	1,512,751	560,000	21,435	1,624,951
7	Package S3	18,350	2,170,264	118,000	64,225	2,364,705
8	Pak Tho IC	1,650	1,120,301	679,000	200,693	1,388,212
9	Package S4	19,700	2,961,284	150,000	55,160	3,194,121
10	Package S5	19,450	2,557,907	132,000	54,460	2,765,841
11	Phetchaburi IC	2,000	323,739	162,000	5,168	348,332
12	Tha Yang IC	1,950	1,182,900	607,000	12,630	1,266,504
13	Package S6	14,600	1,329,419	91,000	51,100	1,460,284
14	Package S7	12,200	1,441,772	118,000	170,800	1,899,078
15	Cha Am IC	2,100	285,429	136,000	207,503	510,058
	Total	134,300	25,004,647	186,000	1,246,959	27,751,885

8.5 ANNUAL MAINTENANCE COST

Annual maintenance cost consists of the following items;

- Routine Maintenance Work
- Periodic Maintenance Work
- Emergency Maintenance Work

The annual maintenance cost is estimated by using the data collected from Japan, Malaysia and ETA. Referencing a JICA study in Malaysia, 0.5% of construction cost is applied for annual maintenance and operation cost.

9. ECONOMIC AND FINANCIAL EVALUATION

9.1 ECONOMIC EVALUATION

The total *economic costs* for evaluation, in which transfer items such as taxes and duties are excluded from the market prices, are estimated, and the annual operation and maintenance costs are estimated at 0.5% of the total construction costs excluding the land acquisition costs.

The economic benefits calculated quantitatively are classified into two types, i.e. i) Savings in Vehicle Operating Costs (VOCs) and ii) Savings in Travel Time Costs. The updated unit VOCs are prepared based on the standardized method which has been adopted by DOH and the unit time costs of passenger vehicles are calculated applying the average wage data.

Calculation results shows that both L-D Rt. and B-C Rt. are economically feasible with 14.08% and 23.02% of *economic internal rate of return (EIRR)* respectively. The implementation of projects will be justified from a view point of national economy.

SUMMARY OF ECONOMIC EVALUATION

Indicator \ Route	L/D Route	B/C Route
EIRR (%)	14.08 %	23.02 %
NPV (Million Baht)	4,412	30,286
B/C Ratio	1.31	2.98

Note: 1. Toll rate = 1.0 Bt./km
2. Opportunity cost of capital = 12%
3. NPV = Net Present Value

Economic sensitivity analysis presents that L-D Rt. will not be feasible in the case of changing both costs and benefits more than 15 % up and down. On the other hand, an EIRR of more than 18 % is still maintained for B-C Rt., even if the costs go up by 20 % and benefits go down by 20 % simultaneously.

ECONOMIC SENSITIVITY ANALYSIS

(Lampang - Dol Saket Route)	Base Case 14.08%	Cost : +10 %	Cost : +15 %	Cost : +20 %
		13.32%	12.98%	12.65%
Benefit : -10 %	13.25%	12.51%	12.18%	11.86%
Benefit : -15 %	12.60%	12.08%	11.76%	11.44%
Benefit : -20 %	12.34%	11.64%	11.31%	11.01%

(Ban pong - Cha Am Route)	Base Case 23.02%	Cost : + 10 %	Cost : + 15 %	Cost : + 20 %
		21.85%	21.32%	20.82%
Benefit : -10 %	21.73%	20.61%	20.10%	19.63%
Benefit : -15 %	21.05%	19.96%	19.46%	19.00%
Benefit : -20 %	20.35%	19.29%	18.80%	18.35%

BENEFIT CALCULATION

(Lampang - Dol Saket Route)

Year	Benefits of Normal Traffic: With or Without	VOC (1000Baht/day)	Time Cost (1000Baht/day)	Benefit (Million Baht/year): VOC Saving	Time Saving	Sub-Total	Benefits of Induced Traffic (Million Baht)	Total Benefits (Million Baht)
2000	W/O	886,465	104,766					
	With	886,186	104,672	101.8	34.3	136.1	0.4	136.5
2010	W/O	2,070,310	478,987					
	With	2,059,448	476,461	3,964.6	922.0	4,886.6	25.2	4,911.8
2020	W/O	4,207,614	1,808,476					
	With	4,193,673	1,786,531	5,088.5	8,009.9	13,098.4	327.6	13,426.0

(Ban Pong - Cha Am Route)

Year	Benefits of Normal Traffic: With or Without	VOC (1000Baht/day)	Time Cost (1000Baht/day)	Benefit (Million Baht/year): VOC Saving	Time Saving	Sub-Total	Benefits of Induced Traffic (Million Baht)	Total Benefits (Million Baht)
2000	W/O	888,378	106,817					
	With	886,318	104,665	751.9	785.5	1,537.4	28.8	1,566.2
2010	W/O	2,083,302	491,784					
	With	2,060,255	479,057	8,412.2	4,645.4	13,057.5	601.2	13,658.7
2020	W/O	4,233,168	1,820,803					
	With	4,193,904	1,792,531	14,331.4	10,319.3	24,650.6	982.8	25,633.4

9.2 FINANCIAL ANALYSIS

The financial costs based on market prices and including taxes and duties and the operation and maintenance costs at 0.5% of total costs excluding land acquisition costs were estimated.

Toll revenues are calculated through the traffic assignment process and compared with the above financial costs.

TOLL REVENUE

Route	Toll Revenue (Million Baht/Year)			
L/D Route	Year	2000	2010	2020
	Fixed Rate	(1.0 Baht/km)	(1.0 Baht/km)	(1.0 Baht/km)
		76.8	635.5	2122.4
	(*) Revised Rate	(1.16 Baht/km)	(1.55 Baht/km)	(2.09 Baht/km)
		78.9	375.5	4275.1
	Toll Revenue (Million Baht/Year)			
B/C Route	Year	2000	2010	2020
	Fixed Rate	(1.0 Baht/km)	(1.0 Baht/km)	(1.0 Baht/km)
		1122.3	3436.7	6418.9
	(*) Revised Rate	(1.16 Baht/km)	(1.55 Baht/km)	(2.09 Baht/km)
		1230.3	4848.8	11843.8

Note : Periodical Toll Revision = Every 5 year interval (3.0% p.a.)

Estimation of *financial internal rate of return (FIRRs)* and comparison between average interest rates of various fund resources with FIRR in realistic assumptions (cost escalation and revised toll rates) are carried out. According to their results, B-C Rt. will be financially viable with a FIRR higher than the average rates of interest of the candidate loan resources, as in the table below. As for L-D Rt., it can be financially viable only if the Government funds and unburden loans are available. The case of combined pool system with L-D Rt. and B-C Rt. indicates a recommendable result to maintain a financial base for both routes.

Examinations of *the repayment program* results that L-D Rt. alone will generate the accumulated net surplus 24 years after opening, even if the most unburden fund combination in assumed options is applied. The combined pool system with L-D and B-C routes will generate the accumulated net surplus from the year of 2029 that is 28 years after opening, if the most burden fund combination in all options is adopted.

SUMMARY OF FIRR (%)

Route	Costs (Financial)	Toll Rate: Fixed (1.0 Baht/km)	Toll Rate: Periodically Revised
L/D Route	1994 Constant Prices	1.45%	4.45%
	Cost up (5.0 % p.a.)	-0.96%	2.57%
B/C Route	1994 Constant Prices	9.54%	12.32%
	Cost up (5.0 % p.a.)	7.51%	10.37%
Combined Pool System (L/D + B/C)	1994 Constant Prices	6.30%	9.13%
	Cost up (5.0 % p.a.)	4.25%	7.25%

COMBINATIONS OF FUND RESOURCES

Case No.	Fund Resources				L/D Route FIRR = 2.57%	B/C Route FIRR = 10.37%	(L/D) + (B/C) FIRR = 7.25%
	Local Portion		Foreign Portion		Average Interest Rate	Average Interest Rate	Average Interest Rate
	GOT (DOH)	Local Loans	IBRD	OECF			
Case 1	●	-	●	-	4.91%	3.78%	4.35%
Case 2	●	-	-	●	1.83	1.41	1.62
Case 3	-	●	●	-	9.40	9.88	9.64
Case 4	-	●	-	●	6.32	7.51	6.91
Loan Conditions:			Composition Ratio	Local	0.39	0.53	0.46
				Foreign	0.61	0.47	0.54

IBRD : Interest Rate 7.30 % p.a., Repayment Period 20 years (including 5- year Grace Period, Commission of 0.75 % p.a. on outstanding amount.
OECF : Interest Rate 3.00 % p.a., Repayment Period 25 years (including 7- year Grace Period.
Local Loans : Interest Rate 11.5 % p.a., Repayment Period 10 years with no Grace Period.

10. SOCIO-ECONOMIC EFFECTS

Promotion of Regional Development:

Regional development play an important role in achieving suitable economic growth, dispersing income and economic advance to rural areas and improving quality of life. Extending socio-economic zone by motorway construction greatly contributes to promote the regional development in terms of reducing the travel time.

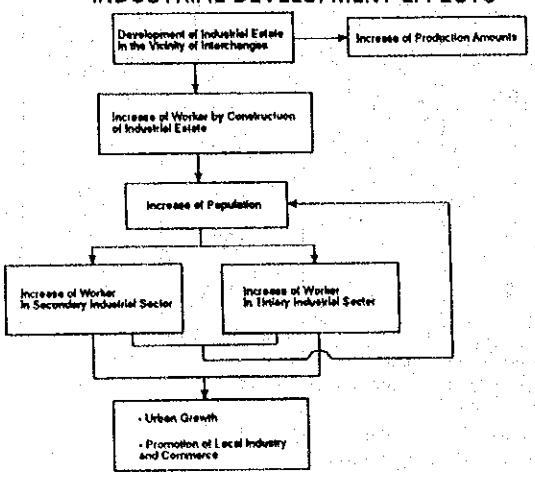
Population in the areas linking to Chiang Mai by car within 4 hours (covered population within 4 hours) increases 910,000 along L-D Rt. and covered population within 2 hours linking to Ratchaburi increases 358,000 along B-C Rt.

COVERED POPULATION BY TRAVEL TIME
(Unit:thousand persons)

Travel Time	Without project	With project	Impact
L-D Rt.			
1 hour	1,126	1,126	0
2 hours	1,891	2,047	156
3 hours	2,687	2,961	274
4 hours	3,776	4,686	910
B-C Rt.			
1 hour	1,337	1,753	416
2 hours	2,909	3,267	358
3 hours	3,546	3,825	279
4 hours	4,030	4,167	137

Promotion of Manufacturing Industry:

INDUSTRIAL DEVELOPMENT EFFECTS



Manufacturing industry in the affected zones by motorway construction is certainly promoted because of that the factories and related facilities will be newly attracted along the motorways providing high accessibility and that the existing factories in the same zones will enable to increase their productivity by means of investing the capital and inputting additional labors.

Promotion of Tourism:

Motorways providing smooth and safe mobility enable to promote tourism industry through increase of the tourists and expansion of the tourism spots.

It will take 2 hours on B-C Rt. from Bangkok to Hua Hin and Cha Am, while motorway connecting L-D Rt. to Chiang Rai and Sukhothai will provide one-day-trip from Chiang Mai to these tourism spots.

Promotion of Agriculture:

The effects to agricultural industry along the newly constructed motorways are expansion of market and improvement of agricultural structure by decreasing time distance to urban growth center.

Both L-D and B-C routes will expand the agricultural economic zones of Changwat centers and influence the agricultural structure in these zones to increase amount and kinds of products.

Promotion of Commerce:

When access to a large city is improved, anybody can easily enjoy shopping in such city. As a result, whole commerce will be active and attractive because of retailer's effort and competition among them.

Improvement of Living Condition:

The improvement in transportation condition through motorway construction will help people in a rural area in utilizing and gaining easy access to such social facilities as government offices, schools, hospitals, etc.

located far from their residence. Furthermore, they will be able to enjoy shopping, theatrical performances, sports games, etc. in Chanwat center. Accordingly, life style of people will be wider without changing their residences.

Increase in Resources Values and Changes of Landuse:

The construction of new motorways will increase accessibility to/from the areas adjacent to new interchanges. This increase in accessibility will increase attraction of such land as new location sites for industrial, commercial and residential uses. The land around interchanges, therefore, can be used more efficiently than as it is, and hence the resource values of land will be increased.

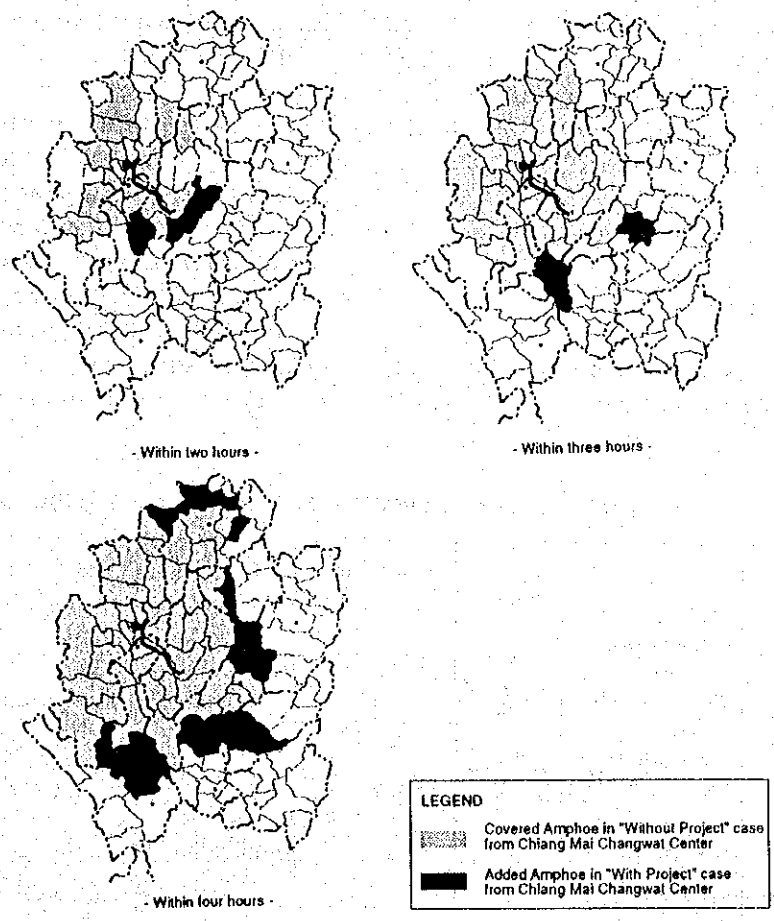
Improvements in Production and Transpiration Scheduling:

Under the new motorway network, producers and transporters of commodities will be able to realize their on-time activities. They need not, therefore, to keep extra raw materials or products as stocks. This will result in reduction of inventory costs. In addition, they can re-form their transportation schedule including the improved re-allocation of vehicles and crews.

Creating New Demands through Road Investments-Multiplier Effects:

As the construction of motorways will require a huge scale investments, it will create huge demands in related economic sectors. That is called as multiplier effects which will promote regionwide/nationwide economic growth and will generate a large number of employment opportunities in the local areas.

COVERED AMPHOE BY TRAVELING TIME ON L-D RT.



11. PROJECT IMPLEMENTATION AND RECOMMENDATIONS

11.1 IMPLEMENTATION SCHEDULE

Project implementation is divided into two main activities: preconstruction activity including detail design, bidding and land acquisition, and construction activity.

The proposed 4-year construction period of L-D Rt. is depending on the first tunnel (3,800 m) and high pier viaduct construction, while the 3-year construction periods of other sections including interchanges along the routes is estimated based on the experiences of national highway construction.

The proposed implementation schedule shows that the detail design will start in the middle of 1995 and the projects will be completed in 2001 for L-D Rt., in 2000 for B-C Rt.

Overall project costs are 27.6 Billion Baht (L/C=39%,F/C=61%) for L-D Rt. and 27.8 Billion Baht (L/C=53%,F/C=47%) for B-C Rt. The peak demand for implementation of the projects are 9.4 Billion Baht in 1999 for L-D Rt. and 11.0 Billion Baht in 1998 for B-C Rt.

11.2 RECOMMENDATIONS

Project Implementation:

The two routes under this feasibility study, showing technical, economical and financial viability, are urgently needed in order to support the rapid growth in socio-economic development in Thailand. The Study strongly recommends the early implementation of the two motorway routes in accordance with the shown overall implementation schedule.

This project forms a part of the nationwide 4,300 km motorway network developed in the master plan study. The implementation of the other sections of the network should also be pursued.

Design Standards for Smooth and Safe Mobility:

Providing higher service to motorists on motorways require the selection of higher design speeds for the different motorway sections. The adopted design speed of 120 km/hr for sections in rural flat areas gives the basic criteria which controls all other geometric design elements.

To handle the future traffic demand, a carriage way of 2 or 3 lanes for each direction is provided. The lane width of 3.75 m is required to provide smooth and safe mobility on the motorways. The carriageway contains shoulders on both sides and a depressed median with 13.50 m width for efficient drainage. Barriers for traffic and glare-prevention are provided for control access and

GENERAL OVERALL PROJECT IMPLEMENTATION SCHEDULE

Route	Items	Duration (Months)	1995	1996	1997	1998	1999	2000	2001	2002
N-Route (Lampong-Dol Saket)	Detailed Design	18								
	Land Acquisition	24								
	Bidding	7								
	Construction	48								
	Openning									
	Annual budget	(%)	1	2	5	14	34	29	15	
	Accumulative Budget	(%)	1	3	8	22	56	85	100	
S-Route (Ban Pong-Cha Am)	Detailed Design	18								
	Land Acquisition	24								
	Bidding	7								
	Construction	36								
	Openning									
	Annual budget	(%)	1	1	3	40	33	22		
	Accumulative Budget	(%)	1	2	5	45	78	100		

safety in addition to buffer zones for the protection of roadside environment. The same concept for the design standards is also applied on all the facilities of the motorways.

Harmony and Conservation of Environment:

Appropriate mitigating measures should be applied to alleviate negative environmental impacts of the project implementation based on the preliminary design on the 10 studied items of; air quality, noise, vibration, water resources and aquatic ecology, soil conditions, terrestrial ecology, transportation network, land-use pattern socio-economic conditions and cultural/aesthetic/archaeological values. Environmental conservation targets are established quantitatively from scientific aspects; however, some environmental parameters are difficult to be evaluated quantitatively, in which a qualitative way of evaluation targets is considered.

Effective Operation and Management System:

The Study proposes that the construction and operation of some sections of the motorway network should be executed by the DOH until a new state enterprise is created. In the mean time, it is urgently required to establish a motorway organizing committee to develop policy and strategy and to study the required legal, economic and engineering issues. The inter-city motorway enterprise should be under the supervision of the Ministry of Transport and Communications with the specific objectives of financing, constructing and operating the 4,300 km motorway network.

Funds for implementation can be acquired thorough public investments, government subsidy and private financing. As the network is connecting all major regions and cities, the applicable toll system should be a closed system with a toll based on the traveled distance. For the operation and maintenance of the whole network, an approximate number of 11 division offices and 90 district offices are required. In addition, a traffic control system and traffic safety facilities are required to ensure the safe operation of the motorway network.

Unburdened Financial Investment Program:

The study routes, Lampang - Doi Saket and Ban Pong - Cha Am routes are economically feasible and the implementation of the both routes are justified from the view point of national economy.

Regarding the Lampang - Doi Saket route, even though it is economically feasible, an Internal Rate of Return (IRR) and other evaluation indicators are not so high because of comparatively higher construction costs for the tunnels and viaduct. It must be pointed out, however, that the regional development effects by the Lampang - Doi Saket route are expected to generate the new development traffic and those traffic will push up the values of EIRR and FIRR to the higher sides.

The Ban Pong - Cha Am route can be financially viable with its guaranteed traffic demands. In the case of Lampang - Doi Saket route, the Government funds will be essential for the implementation.

In order to maintain the financial soundness, it will be necessary to revise the toll rates periodically by referring to the actual economic growth and other cost push factors. The pool system may be recommendable in order to expand the motorway network to cover the low traffic demands and hence low profitable areas/regions where the BOT by private sectors have no incentives to investments in the toll motorways.