tion should be established under the Ministry of Transport and Communications to complete effectively the nationwide toll motorway network in a possible short period.

When agencies related to the government are newly established, they usually take time. Therefore, DOH must construct and operate toll motorways through its existing organization during a preparatory period by the time when the public corporation is established.

9.2.2 Organization of DOH in the Preparatory Period

The organization of DOH is shown in Figure 9.7.

The existing organization structure is sound and functions quite well. If it is a short period, DOH can manage directly to construct and operate toll motorways without any modification.

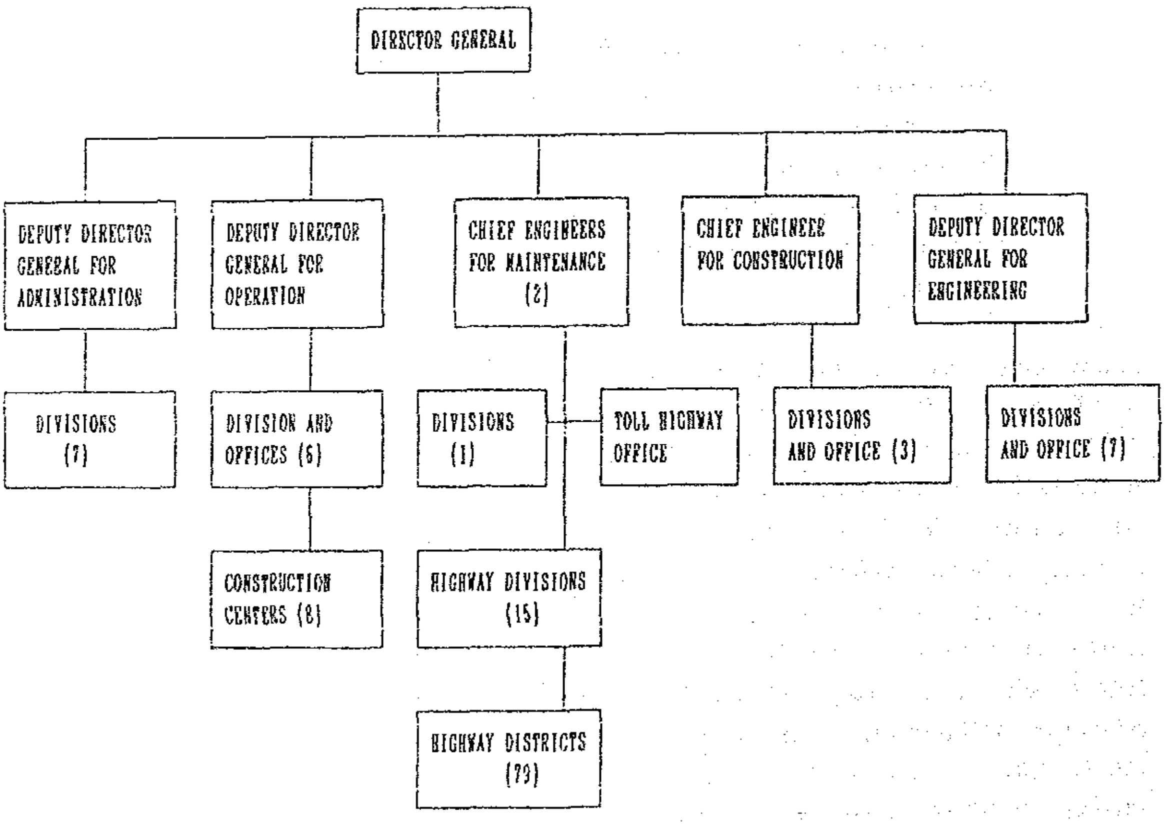


Figure 9.7 GENERAL ORGANIZATION OF DOH

For the toll motorway implementation as well, it will be enough that each sector of the existing organization carries out the following same functions as it used to do:

- Deputy Director General for Engineering and his divisions and offices: Planning and detailed design activities.

- Chief Engineer for Construction and his divisions and offices: Construction activities.

- Chief Engineers for Maintenance and their divisions and offices: Maintenance and operation activities. On-site maintenance works will be carried out by highway districts. The toll highway office has the responsibility of toll collection.

Work volumes of DOH, however, will be at least twice as much as it used to be by adding road works of toll motorways. In order to deal with this added works, a considerable number of staff should be increased. They will be transferred to the public corporation after its establishment.

For studying basic systems for implementation and operation of toll motorways and functions and organization of the public corporation to be established, it is recommended to set up a preparatory committee with an authority in charge in the Ministry of Transport and Communications.

Major items to be studied by the preparatory committee are as follows:

- Laws for toll motorways and the establishment of the public corporation
- Financial resources for the implementation of toll motorways
- Basic plan of the development of the motorway network
- Economic and financial feasibility of toll motorways
- Roles and functions of agencies related to toll motorways
- Size and organization of the public corporation
- Toll fee and toll collection systems

9.2.3 Proposed Public Corporation

1) Role

Roles to be played by the public corporation which the study recommends to be established are described below with those of the government and concession companies, if any.

The specific responsibilities of the public corporation in the overall implementation flow shared by the government, public corporation and concession company respectively, will be stipulated by the law related to the establishment of the public corporation. In this stage, the Study would like to propose the following roles (or authorities), with in mind these two main objectives:

i. To construct and organize, as well as to maintain, the exclusive toll motorway system.

ii. To handle all the business in relation to the operation of the toll motorway system.

The roles are:

- To manage all equipment, facilities and its property.
- To plan, survey, design the motorways in details, and in conformity to the basic plan established by the government.
- To construct motorways.
- To operate the works of the maintenance, traffic operation and control, and toll collection.
- To issue bonds and other financial instruments for investment promotion.
- To supervise concession companies (if any).

The responsibilities of the Government (Department of Highways, Ministry of Transport and Communications) are assumed to be as follows:

- Establishment of the basic plans
- Supervision of the public corporation
- Decision and approval of financial matters such as capital fund, subsidies, issuing bonds, borrowing from financial institutions, etc.

- Granting concession contracts (if any)
- Decision and approval of the toll fee

In case of adopting the concession system, the responsibilities of the concession company are assumed to be as follows:

- Detailed planning and design
- Construction
- Operation of maintenance, and some portion of traffic operation and toll collection

These responsibilities will be applied only for contracted sections.

2) Organization

The Expressway and Rapid Transit Authority of Thailand (ETA), which was established in 1972 and has had long experience in implementing the expressway system in Bangkok Metropolis, is a public corporation with the similar roles to that of the public corporation which are proposed in the Study. Major difference is that the proposed corporation covers the whole areas of Thailand while ETA is concentrated in the Bangkok Metropolis.

The relation of the two corporations is also similar to that of the Tokyo Metropolitan Expressway Public Corporation and the Japan Highway Public Corporation in Japan, even though ETA is under the Ministry of Interior and the proposed corporation is under The Department of Highways, Ministry of Transport and Communications in Thailand, while the two corporations in Japan are under The Ministry of Construction.

In any way, the proposed public corporation will have a hierarchical structure, that is, a headquarter, division offices, on-site offices, laboratory and training center, just as the Japan Highway Public Corporation and the corporations in various countries with nationwide coverage do. Major roles of respective offices can be roughly described as follows:

Headquarter:	Sets the basic technical specifications and basic managerial polices.
Division Bureaus:	Act in accordance with polices laid down by the head quarter within their jurisdictions.

On-site Offices:	Carry out all necessary in-the-field works within their jurisdictions.
Laboratory:	Conducts research to solve engineering problems and develops new methods.
Training Center:	Indoctrinates and trains staff of the public corporation.

This organizational structure can be illustrated as in Figure 9.8. Organizations of respective offices of the public corporation required in the peak stage of its activities are assumed as follows:

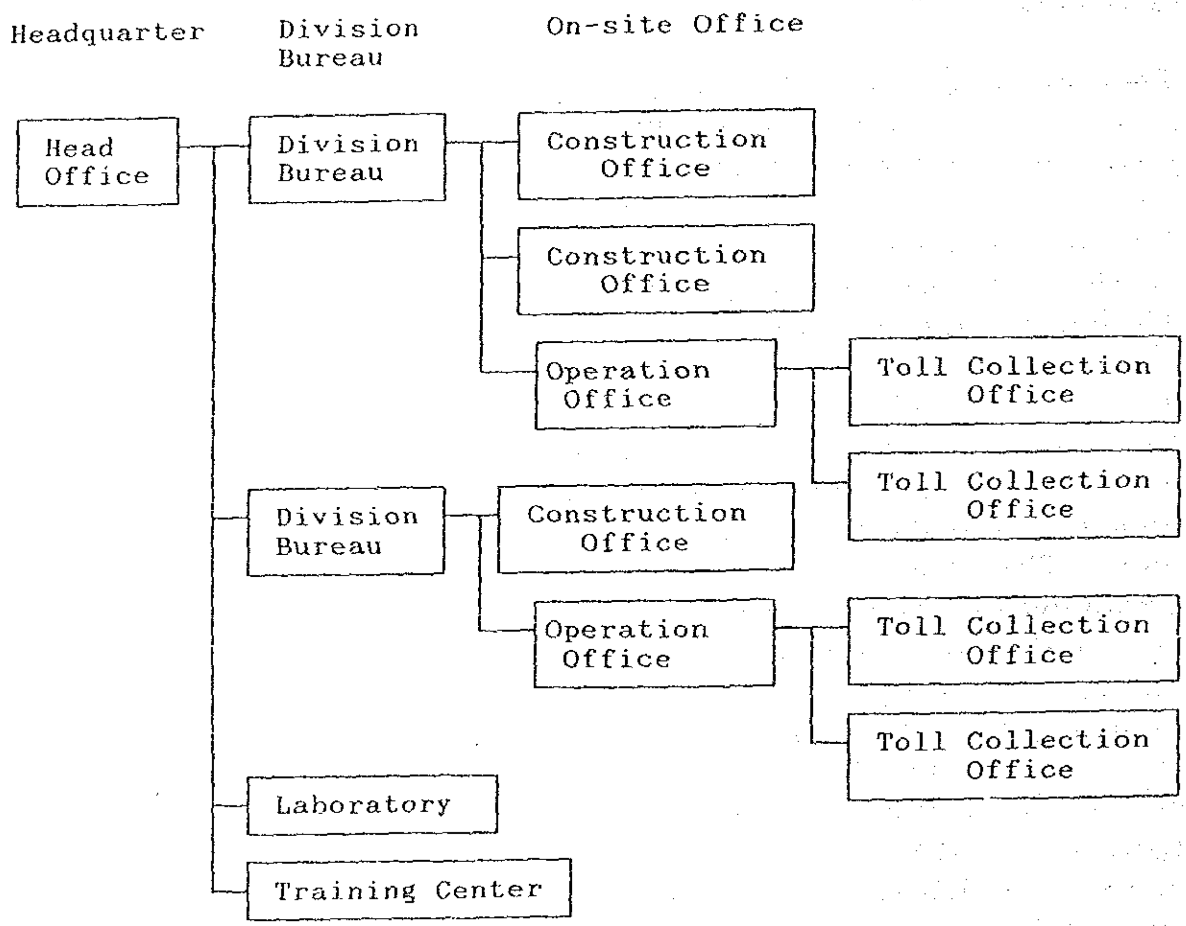


Figure 9.8 ORGANIZATIONAL STRUCTURE OF PUBLIC CORPORATION

a. Headquarter

Assumed organization of the headquarter is shown in Figure 9.9.

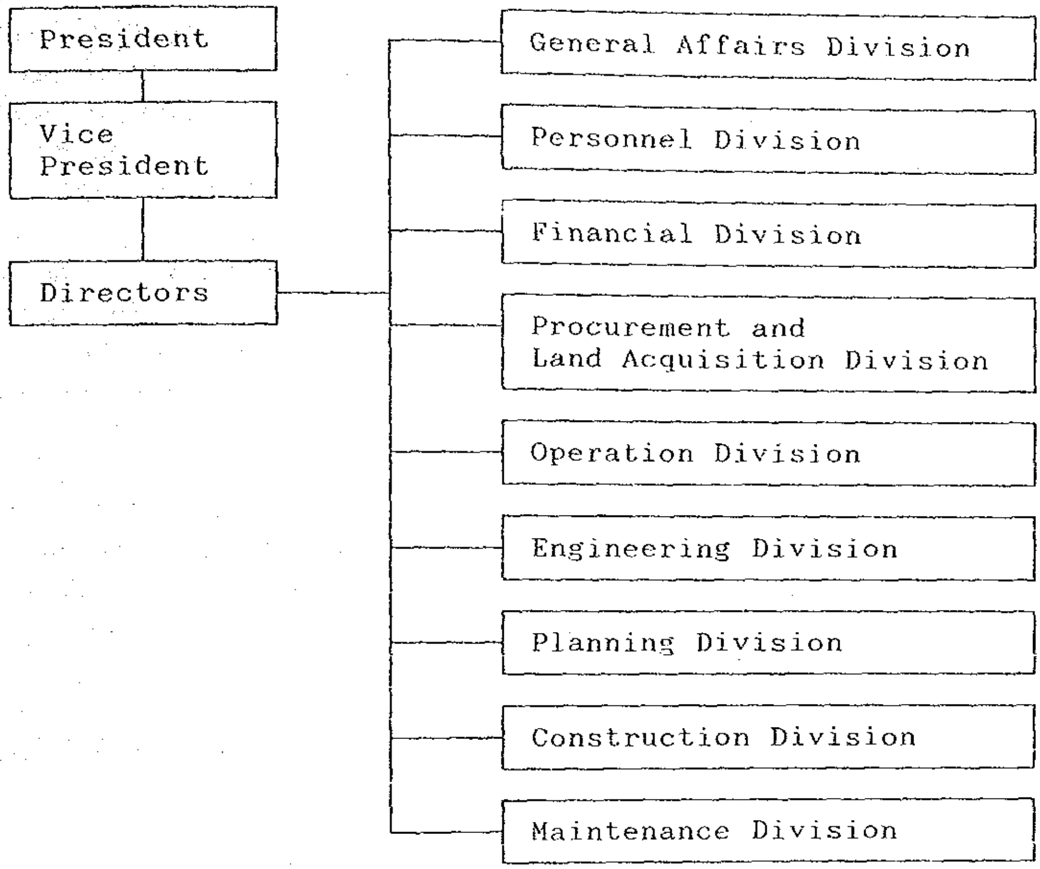


Figure 9.9 ASSUMED ORGANIZATION OF HEADQUARTER

b. Division Bureau

The whole motorway network is usually divided into several divisional-scale coverages, comprising some sections of routes from the viewpoint of easy supervision of construction and operation.

Division bureaus are proposed to be strategically located in some cities and on the suitable places along motorways within their coverages of 400 km to 500 km sections.

Considering a total length of the proposed motorways of about 4,300 km and their route locations, the establishment of the following 9 division bureaus, stated in Table 9.3, is expected.

Table 9.3 EXPECTED DIVISION BUREAU

Region	Division Bureau	Location	Covered Routes
Central	Central 1	Bangkok	TM-31, TM-36 and TM-33
	Central 2	Chon Buri	TM-3, TM-34 and TM-35
	Central 3	Hua Hin	TM-4, TH-36 and TM-32
Northern	North 1	Chiang Mai	TM-1
	North 2	Nakhon Sawan	TM-1
Northeastern	Northeast 1	Khon Kaen	TM-1
	Northeast 2	Nakhon Ratchashima	TM-2 TM-35 and TM-21
Southern	South 1	Surat Thani	TH-4, TM-41 and TM-42
	South 2	Song Khla	TH-4, TM-43

The division bureaus are tentatively called construction bureaus in the construction stage and operation bureaus after the construction work is completed. The division bureau will, therefore, have different responsibilities and organizations in each of the construction and the operation stages.

The main responsibilities of the division bureau are expected to be as follows:

o **In Construction Stage**

- To set up planning and programming of construction within its jurisdiction in more detailed manner than those done by the headquarter.

- To execute tasks such as land acquisition and construction works according to the planning and programming mentioned above.

- To supervise the construction offices.

o **In Operation Stage**

- To manage the operation and activities of all operations and toll offices within its jurisdiction.

- To plan and schedule the maintenance and improvement works.

— To conduct traffic engineering studies for enhancing the efficiency and quality of traffic operation and maintenance.

— To manage the traffic control center in order to facilitate traffic operation.

Assumed organizations of the division bureau in both of the construction and the operation stages are shown in Figures 9.10 and 9.11, respectively.

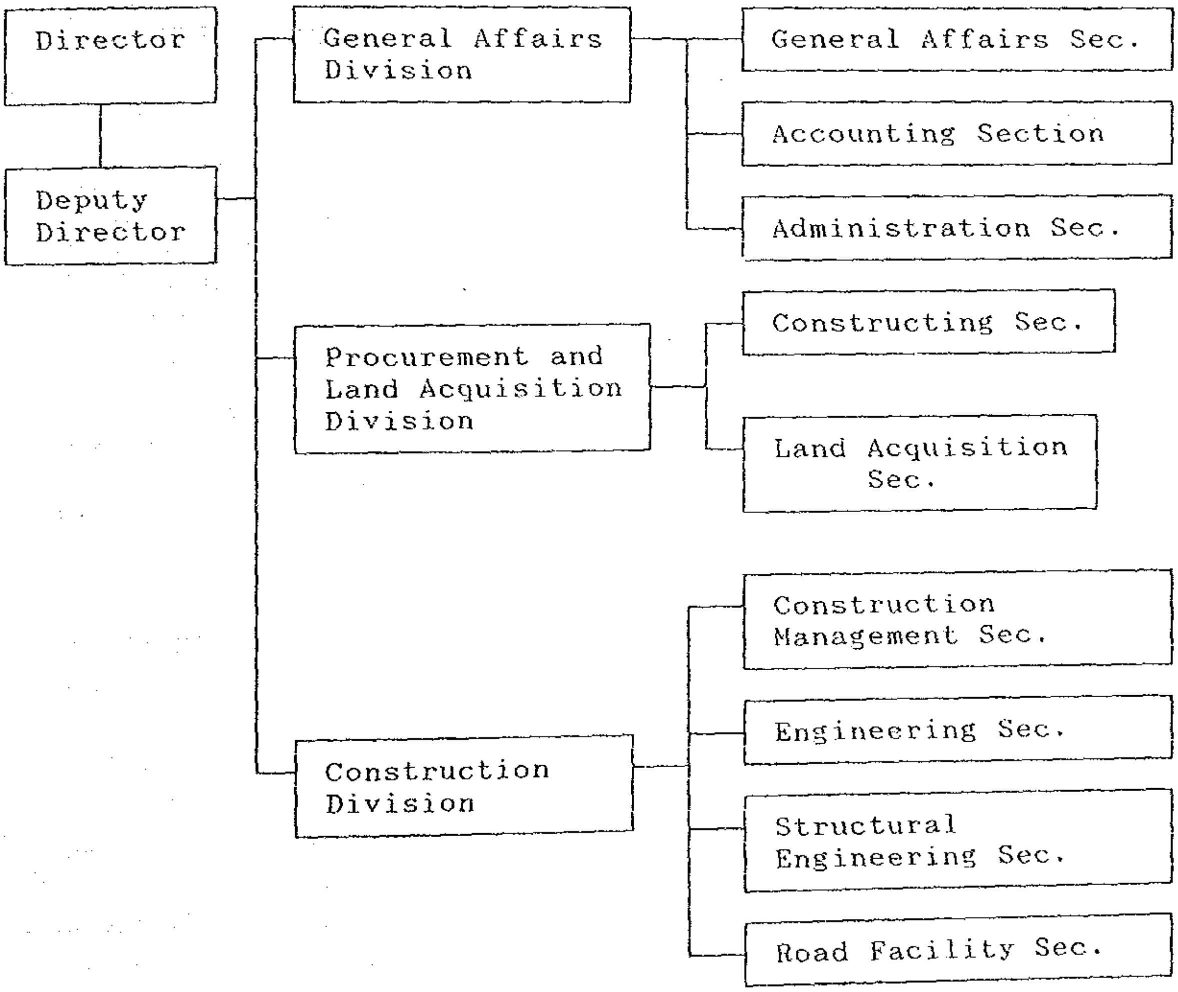


Figure 9.10 ORGANIZATION OF DIVISION BUREAU IN CONSTRUCTION STAGE

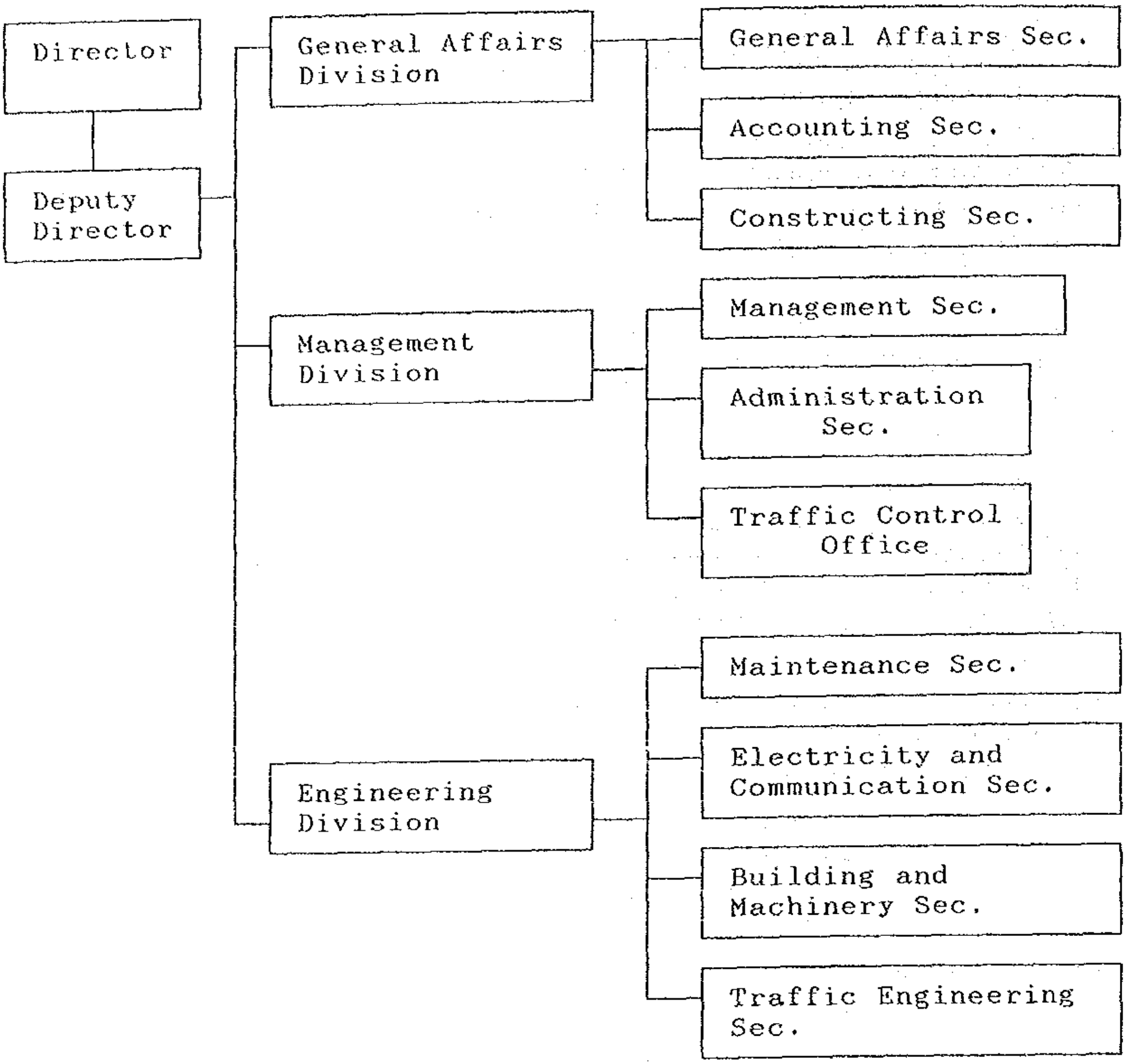


Figure 9.11 ORGANIZATION OF DIVISION BUREAU IN OPERATION STAGE

During the transition period when some sections are completed, while other sections are still under construction, the bureau will have an organization in which these two organizations are combined.

c. On Site Office

The coverages of the division bureau are also divided into sections from the viewpoint of easy in-the-field-activities. Experiences in Japan suggest that the coverage section of the on-site office is about 50 km.

The on-site offices are called construction offices in the construction stage and are located at suitable places for construction supervision within the coverage section. After construction is completed, the construction offices are abolished and the on-site offices which are called the operation offices are established. The operation offices should be located on or near interchanges from the viewpoint of easy access to motorways.

The main responsibilities of the construction office and operation office are as follows:

o **Construction Office**

— To execute, on the site, land acquisition and construction works entrusted by the division bureau.

— To supervise construction contractors and to carry out field construction works within its jurisdiction.

o **Operation Office**

— To carry out field activities such as patrolling, routine maintenance works, first-aid activities and accident disposals.

— To cooperate with the police, who are preferably stationed at the premises of operation offices, and to execute law enforcement and accident investigation.

— To manage the traffic control sub-center in order to facilitate traffic operation.

— To supervise toll collection offices.

Assumed organizations of the construction office and the operation office are shown in Figures 9.12 and 9.13 respectively.

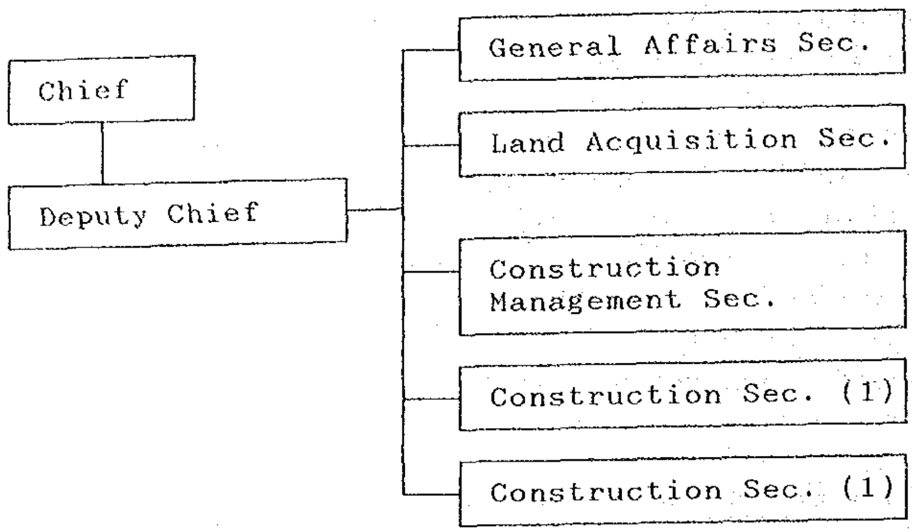


Figure 9.12 ORGANIZATION OF CONSTRUCTION OFFICE

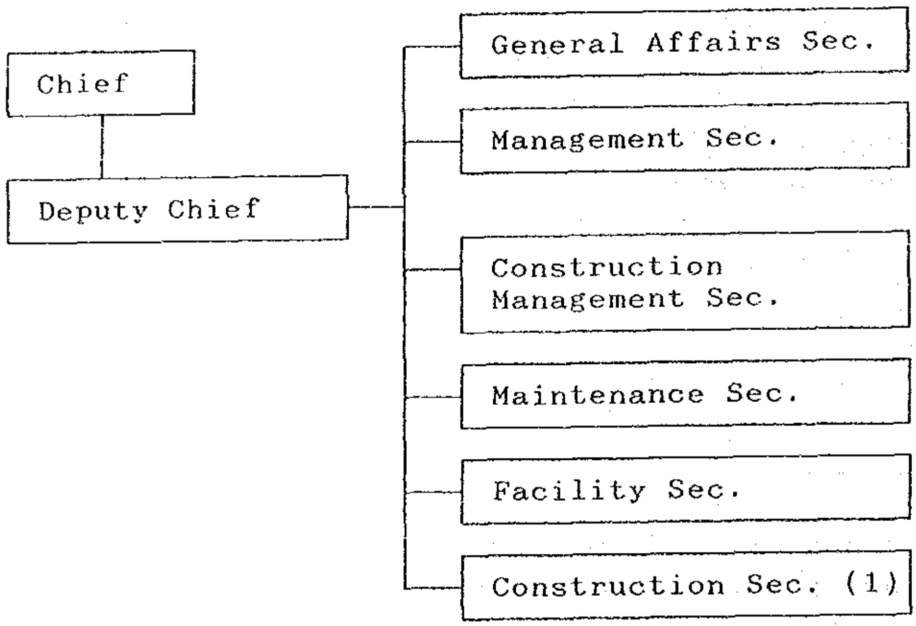


Figure 9.13 ORGANIZATION OF OPERATION OFFICE

On the assumption that motorways of 200 km in length must be completed yearly and one construction office can complete 10 km section a year, at least 20 construction offices are needed.

The length of the coverage section of one operation office is about 50 km. Therefore, 86 operation offices will be required after the whole motorway network of 4,300 km is completed.

d. Toll Collection Office

The toll collection offices will be located at toll gates or plazas erected at the exit points of the motorways. In the proposed nationwide motorway network, 132 toll gates on interchanges and 14 toll plazas on main lines are planned. Therefore a total of 146 toll collection offices will be required after the whole motorway network is completed.

The organization of the toll collection office, in which work will be done on shifts, is assumed to have the configuration shown in Figure 9.14.

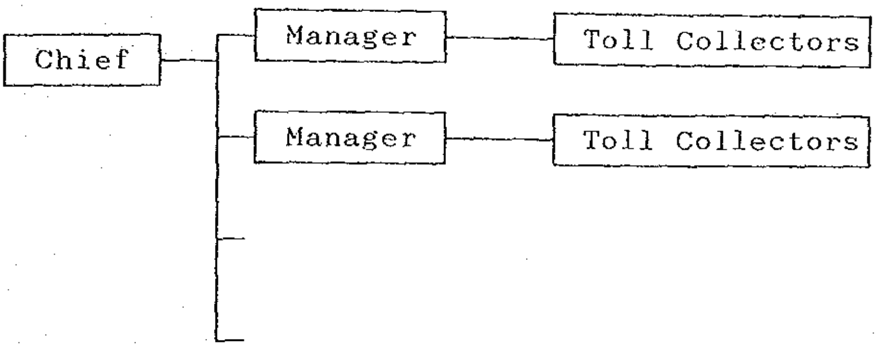


Figure 9.14 ORGANIZATION OF TOLL COLLECTION OFFICE

The number of staff required for the public corporation will differ as its activities expand. The required number of staff after the whole motorway network is completed and opened to traffic is roughly estimated as shown in Table 9.4.

Table 9.4 REQUIRED NUMBER OF STAFF

Office	Number	Average Number of Staff/Office	Total
Head Office	1	500	500
Division Bureau	9	150	1,350
Operation Office	86	50	4,300
Toll Collection Office	146	72 (5)	10,542 (730)
Laboratory	1	100	100
Train Center	1	30	30
Total			≒ 16,800 (7,000)

Note: Figures between parentheses show the case of commissioning toll collection to private companies.

In the transition stage when some routes are still under construction, some construction offices are required instead of the operation offices and the toll collection offices.

The required number of staff of about 16,800 in the above table are estimated on the assumption that most of actual construction and maintenance works are carried out under contract base.

The staff of the toll collection offices occupy more than half of the total staff. If toll collection and other related works can be commissioned to private companies, the staff of the public corporation will be reduced to about 7,000 as shown in a parenthesis of the above table.

9.2.4 Maintenance and Traffic Operation

Motorway maintenance and traffic operation has three goals, namely; ensuring traffic safety, smooth traffic flow and users comfort on the motorways. Such a system has two basic functions; maintenance and traffic operation. Each of these two functions has several components and tasks which are briefly described below.

1) Maintenance

The maintenance function of motorways can be distinctively divided into the following three components;

- Routine maintenance
- Periodical maintenance
- Emergency maintenance

Routine maintenance can be defined as those planned and programmed activities which are required throughout the year, done on a day-to-day basis (pothole patching, ditch cleaning, etc.).

Periodic maintenance is made up of those planned and programmed activities with a recurrent time cycle of more than one year (resealing, resurfacing, etc.).

Emergency maintenance is made up of those unplanned and unprogrammed activities required in the aftermath of slides, flooding, etc.

2) Traffic Operation

The traffic operation has four components, which are:

- Traffic Control
- Traffic Surveillance
- Toll Collection
- Traffic Regulation

The traffic control component here includes not only the general traffic control on motorways under normal conditions as carried out by motorway or police patrol units along the motorways everyday, but also those emergency measures taken for the purpose of controlling traffic under unusual conditions. Such unusual conditions may include traffic accidents, adverse weather phenomena (torrential rain, heavy thunderstorm concentrated at small area, strong wind, fog, etc.) and conditions generated as a result of improvement works to the motorway like widening of carriageway, construction of additional ramp, pavement repairs, etc.

The traffic control component also performs a very important task, that of information dissemination. Road and traffic conditions or weather information gathered at the traffic control centers or sub-centers at the on-site offices are conveyed to other offices, patrol units as well as the drivers via such media as wireless, highway radio, changeable message signs, and broadcasting.

The second component under traffic operation is traffic surveillance. Traffic surveillance is aimed at collecting information on road and traffic conditions using such equipment as vehicle detectors, closed-ircuit television cameras, helicopters (aerial surveillance), emergency telephones and other means as cooperative motorists, mobile telephones, patrol vehicles, etc. Some of these will yield quantitative data while others will provide incident information or level of service. Traffic information collected and processed are interpreted by traffic engineers and pass on to the police or patrol personnel for traffic control.

Toll collection constitutes another component under the traffic operation function. The task here is simple and straightforward, i.e. the collection of toll from vehicles using the motorways at toll gates or plazas erected at the exit points of the motorways (in the case of a closed system) or at toll barriers (in the case of an open system). At toll collection plazas or gates, equipments are also installed for the collection of traffic data. Toll ticketing itself will provide fundamental data such as traffic volume and traffic composition.

Lastly, traffic regulation which is the jurisdiction of the police in most countries, legitimates the various traffic control measures as provided by the governing traffic laws and regulations, such as maximum speed limit control, temporary closure of a lane or even a section of the motorway during an emergency.

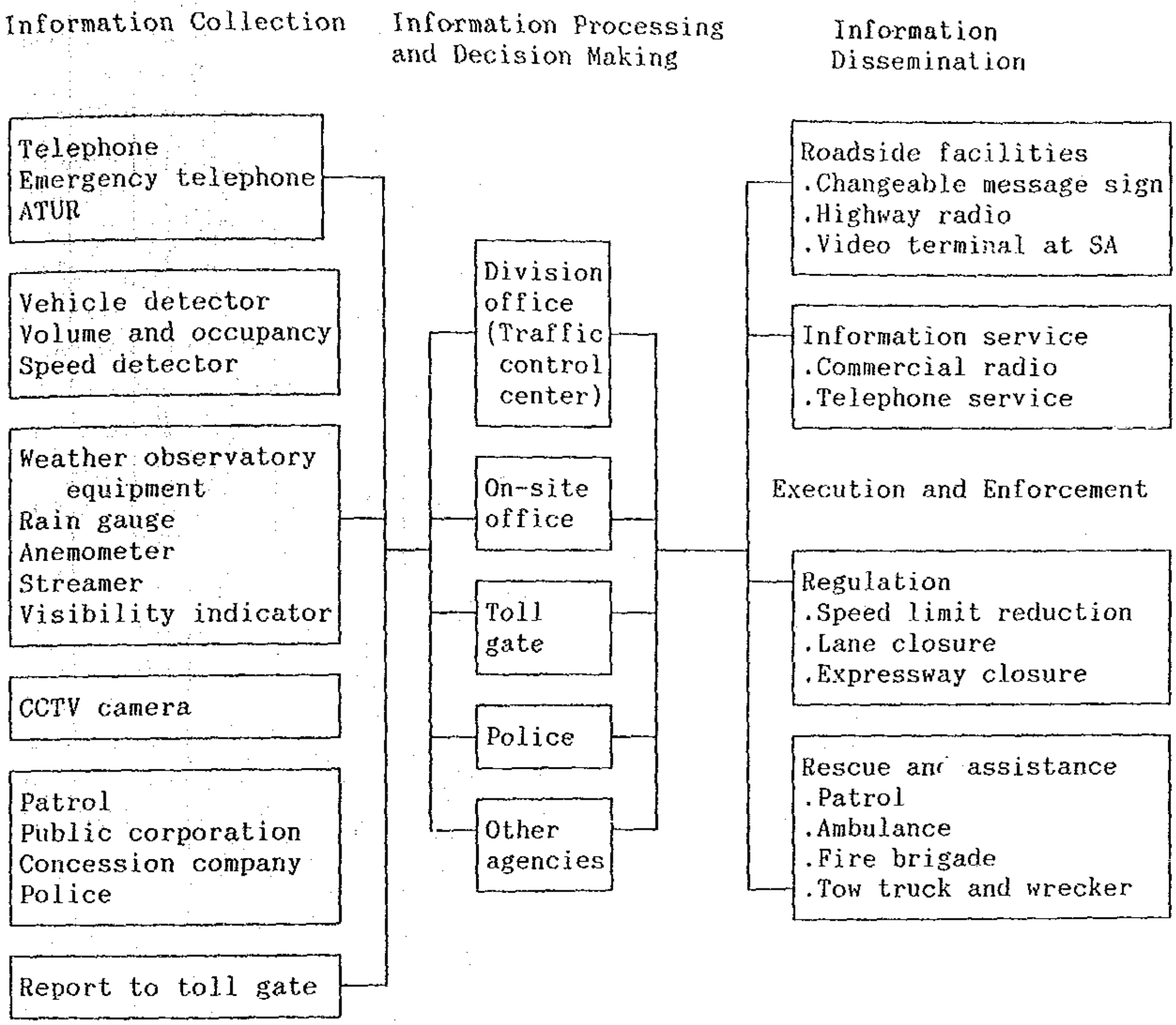
9.2.5 Traffic Control and Management System

1) Outline of Traffic Control and Management System

In order to manage a motorway efficiently and in an organized manner, a traffic control and management system is proposed to be established. The system has four major functions; namely, information collection, information processing and decision making, information dissemination, and execution and enforcement of the decision. Figure 9.15 illustrates the structure of traffic management system and Figure 9.16 depicts the concept of traffic control and management system.

a. Information Collection:

Traffic data and incident information are either automatically gathered through vehicle detectors, weather observatory equipment and other devices, or manually reported through emergency telephone, or radio communication system provided to patrol car. CCTV system is also an essential tool for traffic surveillance as it furnishes system operator with the visual image of traffic situation.



CCTV: Closed circuit television
ATUR: Automobile telephone using radio
SA: Service area

Figure 9.15 TRAFFIC MANAGEMENT SYSTEM STRUCTURE

b. Information Processing and Decision Making:

Traffic control and management center is a kernel of the traffic control and management system. All information is gathered to the center where traffic management activities such as incident detection, assistance to drivers, detour implementation, special enforcement, etc., are activated through monitoring the traffic situation.

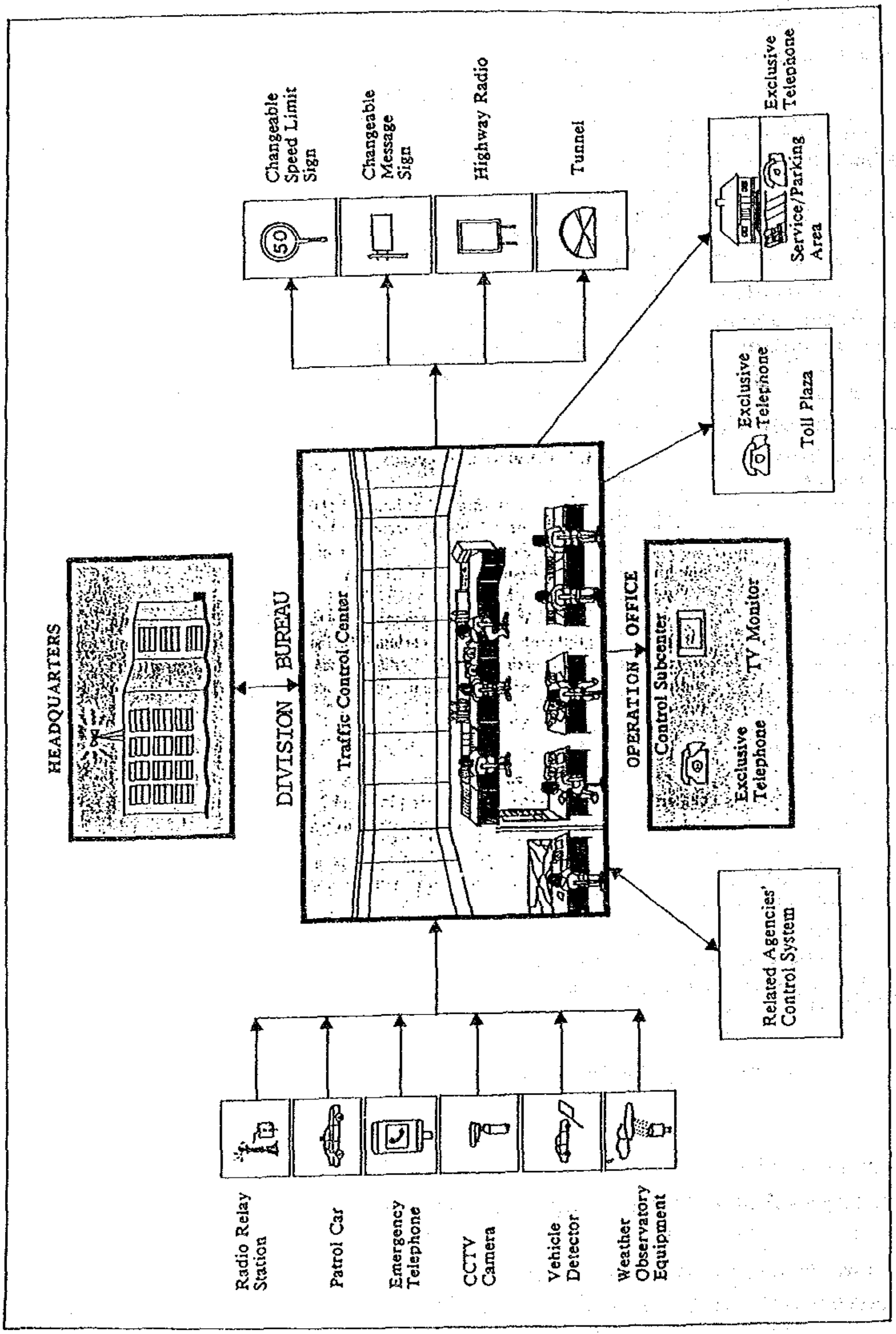


Figure 9.16 CONCEPT OF TRAFFIC CONTROL AND MANAGEMENT SYSTEM

c. Information Dissemination:

Roadside information dissemination devices such as changeable message sign, highway radio, etc., are controlled from the traffic control center so that road and traffic conditions are conveyed to road users and adverse effects by incident and congestion will be mitigated to a minimum.

Information are also provided through video terminal installed at the service area and through telephone service, in which inquiry is answered either by operator or prerecorded massage. These facilities are capable of providing more specific information.

d. Execution and Enforcement:

Should an incident occurs on the motorway, countermeasure must be taken swiftly. There are variety of traffic control measures such as speed limit reduction in case of adverse weather condition, closure of shoulder, closure of one lane, and closure of a section of the motorway. The traffic control must be executed in a coordinated manner by both motorway management body and police, and the traffic control and management center is a core for overseeing such activities.

2) Traffic Control Center and Sub—center

Traffic control center is proposed to be established as a core of the traffic control and management system. It accommodates a computer system and other associated equipments as well as staff for operating the system and planning of countermeasures against incidents.

Sub-center is installed to gather and distribute data for road side equipment, to monitor certain information for prompt execution of countermeasures against incident and to back up the functions of the control center to some extent in case of communication interruption between sub center and center.

a. Composition:

Traffic control center comprises a control room where staff are stationed and control desks, terminals and display panel are located, machine room where a computer, peripherals and other equipment are installed, power room where an uninterruptible power supply system is placed, and other spaces such as office, workshop, storage room, etc.

Sub-center comprises control room where monitoring or control desk are installed and carrier terminal station where a computer, peripherals and data transmission system are located.

b. Location:

Traffic control center is proposed to be set up at divisional offices and certain on-side offices. Besides, sub-center is to be established at the rest of the on-site offices in order to monitor certain information required for management activities such as patrolling, maintenance works and first-aid activities.

c. Connection of roadside equipment:

Roadside equipments are installed at various locations along the motorway, and they are controlled either by one-site office or by control center. Communication network is established among the offices and between offices and roadside equipment. Figure 9.17 illustrates the location of the roadside equipment and how these equipment are connected and operated.

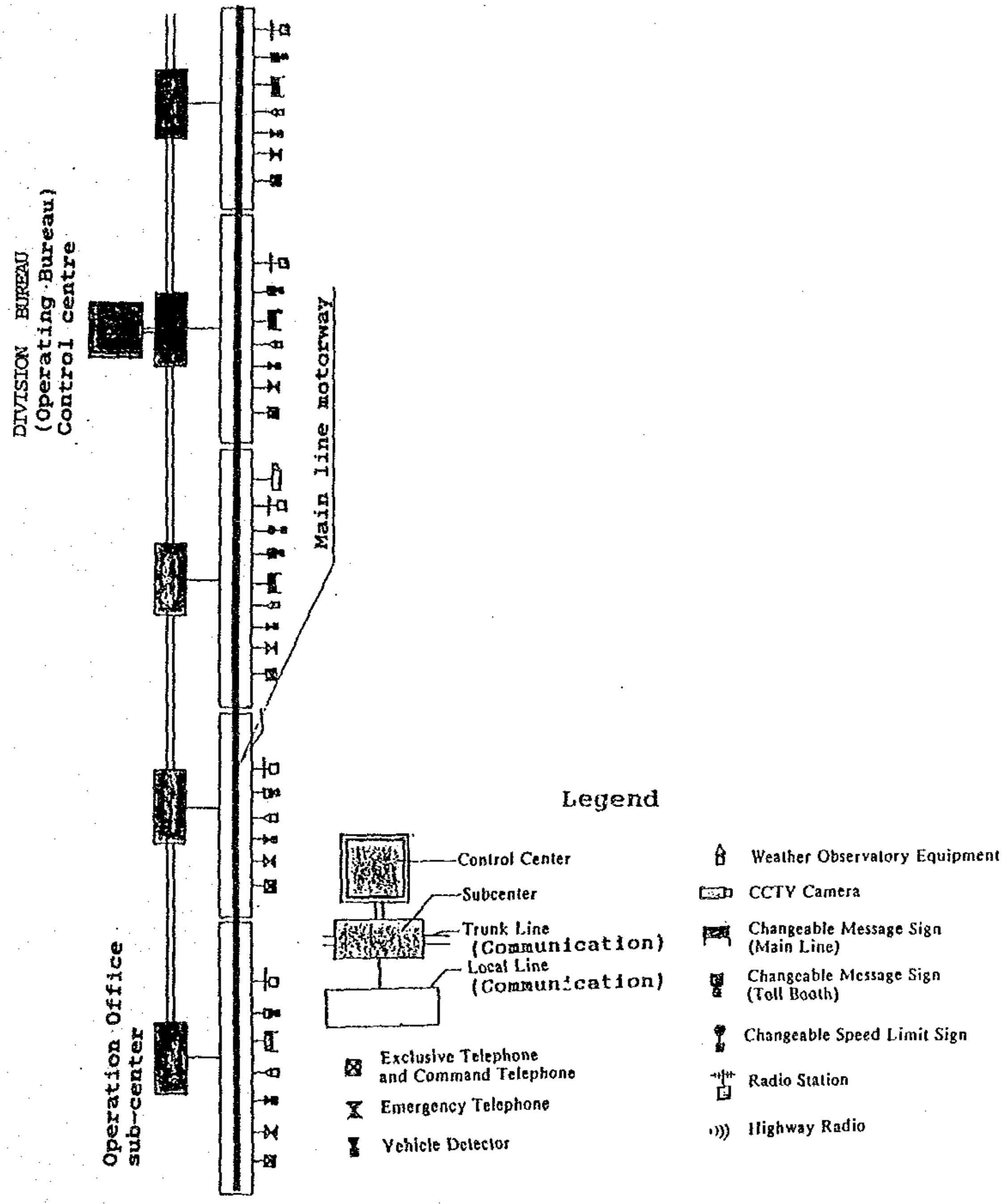


Figure 9.17 EXAMPLE OF TRAFFIC CONTROL AND MANAGEMENT PLAN

CHAPTER TEN

ECONOMIC EVALUATION

CHAPTER 10

ECONOMIC EVALUATION

10.1 CONSTRUCTION COSTS

The construction costs for the routes of the motorway network are estimated for each link between two interchanges including junctions of each proposed route.

For common major work items, construction costs are calculated by applying standard costs per kilometer derived from the analysis of typical sections selected in consideration of road and terrain characteristics.

The costs of special road structures such as long span bridges, tunnels, interchanges, rest facilities, etc., are separately estimated depending on the structure size, and added to the construction cost for common major work items.

Costs for land acquisition also separately estimated by typical link and are added to the above construction costs.

10.1.1 Quantities of Major Work Items

Major work items applied in estimating the construction costs are prepared based on main payment items included in the standard specifications and in bidding documents of recent divided highway projects of DOH with some modifications considering the special characteristics of the project.

Quantities of major works are calculated per kilometer base on typical sections classified for the cost estimation by road and terrain characteristics as presented in Table 10.1.

Typical cross sections of these typical route sections are shown in Appendix 10.1.

Table 10.1 TYPICAL SECTIONS FOR COST ESTIMATION

Road Type	Terrain
Four-lane Motorway	Flat (normal and soft grounds), rolling and mountainous
Six-lane Motorway	Flat (normal and soft grounds)
Outer Ring Motorway	Flat (only soft ground)

The calculated quantities of major work items included in the typical sections per kilometer are summarized in Table 10.2.

Quantities of work items which are not shown in Table 10.2, such as interchanges, rest facilities, long span bridges, tunnels, etc., are shown in Appendix 7.14.

Land areas to be acquired are calculated providing that the required width of the right-of-way is 80.0 m. For the Outer Bangkok Ring Motorway, however, no land acquisition is planned, since it is to be constructed within the existing right-of-way.

10.1.2 Unit Costs

The unit costs of major work items are derived from actual contract unit costs in similar highway construction projects of DOH in 1990.

The unit costs thus derived are modified, through discussions with DOH, so that they may present the average unit cost for the whole country. These unit costs are shown in Table 10.3.

The unit costs of work items not included in Table 10.3, such as interchanges, junctions, rest facilities, special structures (long-span bridge, tunnel and main line toll facility), and land acquisition, are shown in Appendix 10.2.

Table 10.2 QUANTITY OF MAJOR WORK ITEMS

Work Item	Unit	4-Lane Flat NG	4-Lane Flat SG	4-Lane Rolling	4-Lane Mountainous	6-Lane Flat NG	6-Lane Flat SG	6-Lane Outer Ring Motorway
Earthwork								
Clearing and Grubbing	m²	49,000	69,000	54,000	58,000	56,000	76,000	45,600
Roadway Excavation (Earth)	m3	-	-	24,300	74,400	-	-	-
〃 〃 (Soft Rock)	m3	-	-	12,150	55,800	-	-	-
〃 〃 (Hard Rock)	m3	-	-	-	46,500	-	-	-
〃 〃 (Unstable)	m3	-	-	4,050	9,300	-	-	-
Soft Spot Excavation and Replacement	m3	820	1,230	-	-	960	1,440	864
Embankment (Excavation)	m3	-	-	36,450	31,000	-	-	-
Embankment (Borrow)(d=20km)	m3	78,000	78,000	17,550	-	92,000	92,000	55,200
Embankment (Berm)	m3	-	40,000	-	-	-	40,000	24,000
Sand Mat	m3	-	34,000	-	-	-	37,500	22,500
Subbase and Base Course								
Subbase	m3	900	900	900	900	900	900	540
Cement Stabilized Base	m3	4,700	4,700	4,700	4,700	5,735	5,735	3,441
Surface Course								
Asphalt Prime Coat	m²	11,000	11,000	11,000	11,000	14,750	14,750	8,850
Asphalt Concrete	m3	225	225	225	225	225	225	135
Portland Cement Concrete Pavement (t=28cm)	m²	17,500	17,500	17,500	17,500	24,500	24,500	14,700
Structure								
RC Pipe Culvert	m	250	370	540	260	320	440	264
RC Box Culvert	m	100	148	108	52	114	162	98
4-lane RC Bridge (Normal Ground)	m	10	-	5	5	-	-	-
〃 〃 (Soft Ground)	m	-	10	-	-	-	-	-
6-lane RC Bridge (Normal Ground)	m	-	-	-	-	10	-	-
〃 〃 (Soft Ground)	m	-	-	-	-	-	10	200
4-lane PC Bridge (Normal Ground)	m	20	-	10	10	-	-	-
〃 〃 (Soft Ground)	m	-	20	-	-	-	-	-
6-lane PC Bridge (Normal Ground)	m	-	-	-	-	20	-	-
〃 〃 (Soft Ground)	m	-	-	-	-	-	20	200
Bearing Unit	m²	-	1.360	-	-	-	1.520	3.040
Over Bridge on 4-lane Motorway	each	0.5	0.5	0.25	0.2	-	-	
〃 〃 on 6-lane Motorway	each	-	-	-	-	0.5	0.5	0.5

NG : Normal Ground
SG : Soft Ground

Table 10.3 UNIT COSTS OF MAJOR WORK ITEMS

Works Item	Unit	Unit Cost (Baht)
Earthwork		
Clearing and Grubbing	m^2	2
Roadway Excavation (Earth)	m3	45
" " (Soft Rock)	m3	70
" " (Hard Rock)	m3	150
" " (Unstable)	m3	35
Soft Spot Excavation/Replacement	m3	320
Embankment (Excavation)	m3	70
Embankment (Borrow) d = 20 Km	m3	200
Embankment (Beam)	m3	100
Sand Mat	m3	280
Subbase and Base Course		
Subbase	m3	280
Cement Stabilized Base	m3	450
Surface Course		
Asphalt Prime Coat	m^2	12
Asphalt Concrete	m3	1,900
Concrete Pavement (t=28cm) (including steel mesh)	m^2	720
Structure		
RC Pipe Culvert	m	2,070
RC Box Culvert	m	15,000
4-lane RC Bridge (Normal Ground)	m	161,000
" " (Soft Ground)	m	214,000
6-lane RC Bridge (Normal Ground)	m	209,000
" " (Soft Ground)	m	278,000
4-lane PC Bridge (Normal Ground)	m	221,000
" " (Soft Ground)	m	255,000
6-lane PC Bridge (Normal Ground)	m	285,000
" " (Soft Ground)	m	332,000
Bearing Unit	m^2	2,800
Over Bridge on 4-lane Motorway	each	13,000,000
" " on 6-lane Motorway	each	14,700,000

10.1.3 Construction Cost

Firstly, the standard cost per kilometer is estimated for the typical sections classified as mentioned in Section 10.1.1 based on the unit costs of the major work items and their work quantities. The standard costs of typical sections are shown in Appendix 10.3. The construction cost is calculated for each link between two interchanges by multiplying the standard cost per kilometer of the typical section corresponding to subject link by the length of the link. After that, construction costs of major work items excluded in the typical sections such as interchanges, long-span bridges, tunnels, rest facilities, etc., are added to the above calculated results.

The cost of miscellaneous works such as slope protection, concrete ditches, guard rails, and traffic signs and markings is estimated at 7 % of the total cost of major work items. The total construction costs are computed by adding the following cost items to the above construction costs:

- Physical contingency : 10 % of direct construction costs
- Design and construction supervision : 10 % of "direct construction costs + physical contingency"
- Land acquisition cost

The estimated financial and economic construction costs for each link are shown in Appendix 10.4, and those summarized for all routes in Table 10.4.

Table 10.4 TOTAL CONSTRUCTION COST BY ROUTE (million Baht)

ROUTE	ORIGIN	DESTINATION	LENGTH (km)	DIRECT CONSTRUCTION COST	PHYSICAL CONTIN-GENCIES	ENGINEERING & SUPERVISION	LAND ACQUISITION	FINANCIAL COST	FINANCIAL COST / KM	ECONOMIC COST
TM-1	O.B.R.R.	CHIANG RAI	755.6	42,553.8	4,255.4	4,680.9	2,676.5	54,166.5	71.7	49,017.6
TM-2	O.B.R.R.	NONG KAI	535.5	29,868.4	2.986.8	3,285.5	1,883.2	38,024.0	71.0	34,409.9
TM-3	PHRA KHANONG	SATTAHIP	231.9	18,972.2	1,897.2	2,086.7	6,373.5	29,329.8	100.5	27,034.3
TM-4	O.B.R.R.	HAT YAI	951.4	52,054.0	5,205.2	5,725.9	4,005.2	66,990.4	70.4	6,0691.7
TM-21	NAKHON RATACHASIMA	UBON RATCHATANI	301.1	15,800.0	1,580.1	1,738.0	903.3	20,021.4	66.5	18,909.6
TM-31	O.B.R.M.		167.7	33,700.0	3,370.0	3,707.0	0.0	40,777.0	243.2	36,639.3
TM-32	O.B.R.R.	KANCHANABURI	100.0	7,415.8	741.6	815.7	1,000.0	9,973.1	99.7	9,075.8
TM-33	O.B.R.R.	SUPHAN BURI	62.0	3,557.3	355.7	391.3	620.0	4,924.4	79.4	4,493.9
TM-34	O.B.R.R.	ARANYAPRATHET	211.7	13,965.1	1,396.5	1,536.2	1,667.5	18,565.3	87.7	16,875.5
TM-35	CHON BURI	NAKHON RATCHASIMA	239.1	16,213.2	1,621.3	1,783.4	1,104.3	20,722.2	86.7	18,760.4
TM-36	RATCHABURI	CHACHOENGSAO	365.8	20.377.0	2,037.7	2,241.5	3,658.0	28,314.2	77.4	25,848.6
TM-41	KRABI	KHANOM	190.7	9,241.1	924.1	1,016.5	953.5	12,135.2	63.6	11,017.0
TM-42	PHRASAENG	PHUKET	136.0	7,046.1	704.6	775.1	680.0	9,205.8	67.7	8,353.2
TM-43	RON PHIBUN	NAKHON SI THAMMARAT	36.9	2,063.7	206.4	227.0	184.5	2,681.5	72.7	2,431.8
TOTAL			4,345.4	272,827.3	27,282.4	30,010.5	25,709.5	355,830.3	81.9	322,818.7

The economic construction costs shown in Table 10.4 are computed by deducting the tax component from the financial construction costs. Applied percentage of the tax component is 10 %. This is determined as quoted values described in the Feasibility Study Handbook for Improvement and New Construction Road Projects (FSH), as well as values applied in the past feasibility studies.

As seen in Table 10.4, the construction cost of the whole network of 4345.4 kilometer in total is estimated at 355,830.8 million Baht and the average cost per kilometer is 81.9 million Baht.

The highest cost per kilometer of 243.2 million Baht is computed for the Outer Bangkok Ring Motorway, since this route is a 6-lane motorway on soft ground and contains many structures including costly long-span bridges.

The second highest cost per kilometer of 100.5 million Baht belongs to TM-3 (OBRM to Chantha Buri). This is mainly caused by high land acquisition cost.

The cheapest cost per kilometer of 63.6 million Baht for TM-41 (Krabi - Khanom) is due to the comparatively cheap land acquisition cost.

10.2 MAINTENANCE AND OPERATION COST

Generally, toll motorways require more amount of maintenance and operation costs than ordinary non-toll highways. This is due to users of toll motorways expect higher level of services, such as safe and on-time driving, at the expense of the toll fee.

Based on the budget of DOH in 1988, the maintenance cost including the overhead is approximately 83,000 Baht/km for their non-toll highways. This is a small amount and can not be considered as a base to estimate the maintenance cost of toll motorways.

No local basic data to estimate maintenance and operation costs are available because there are no existing inter-city toll motorways in Thailand. In the study, therefore, the maintenance and operation costs for toll motorways are estimated referring to the method applied in most countries. In this method, the maintenance costs and the operation costs are classified as follows:

i . Maintenance cost

ii . Operation costs
- Operation office cost
- Toll collection cost
- Traffic control cost

iii . Administration cost (expenditure for a head office, division bureaus, etc.): Total toll revenue per year x 2.0%.

1) Maintenance Cost

Work items required for the maintenance and their unit costs are shown in Table 10.5 withthe estimated actual costs.

Table 10.5 UNIT COSTS OF MAINTENANCE WORK (Baht/km/year)

Work Item	Basic Unit Cost	Proportion of Motorway Length (%)	Actual Unit Cost
Road Cleaning	80,000	100	80,000
Road Maintenance	120,000	100	120,000
Lighting	70,000	1	700
Bridge Maintenance	120,000	1	1,200
Tunnel Maintenance	1,500,000	0.25	3,750
Overlay	70,000	100	70,000
Total			275,650

A total unit cost of the maintenance works is calculated as follows:

(1)	Direct Cost	275,650
(2)	Indirect cost (1) x 10%	27,565
(3)	Administration cost	95,276
	Total	398,491 Baht/year/km

The above administration cost is computed as follows:

- Total toll revenue for 4,300 km motorway
= 54,625,000,000 Baht/year

- Toll revenue/km/year = 12,703,488 Baht/year/km

- Administration cost = 12,703,488 x 1.5%
  ≑ 190,552 Baht/year/km

- 50% of the administration cost is allocated to the maintenance cost and the remaining 50% to the operation cost.

  The administration cost allocated to the maintenance cost
  = 190,552 x 50% = 95,276 Baht/year/km

The maintenance cost/year/km computed thus was checked through analysis of the maintenance costs actually spent in Expressway & Rapid Transit Authority of Thailand (ETA) and JHPC. Table 10.6 shows the operation costs of ETA toll expressways in 1988.

Table 10.6 OPERATION COSTS OF ETA

Item	Cost (million Baht)	Percentage (%)
Administration	39.94	48.1
Operation	22.43	27.0
Maintenance	8.99	10.8
Investment	11.65	14.1
Total	83.01	100

Source: Statistic Report, ETA, 1988.

Based on Table 10.6, the maintenance cost including administration cost concerned was estimated on the basis of the following assumptions:

- 20 % of the amount of administration cost is allocated to the investment work.

- 50 % of the remaining amount of the administration cost is allocated to the toll operation and maintenance works, respectively.

The maintenance cost including the administration cost thus estimated is 24.97 million Baht with an average of 924,000 Baht/km (the total length of ETA toll expressway under operation is 27.0 km). It is approximately 11 times costlier than that of non-toll highways of DOH.

According to "Expressway Handbook, 1989" of the Nationwide Council for Expressway Development, the maintenance cost including administration cost of JHPC in 1988 is 28,000,000 Yen/km. This is equivalent to 5,600,000 Baht/km (1 Baht = 5 Yen) which is about 6 times higher than that of ETA.

It is natural that maintenance cost differs depending on countries, regions, characteristics and conditions of toll motorways, etc. However, the required maintenance cost is said to be in similar proportion to the total project cost regardless any variety in conditions.

Table 10.7 shows percentages of the maintenance cost to the total project cost for ETA and JHPC.

Table 10.7 PERCENTAGE OF MAINTENANCE COST TO TOTAL PROJECT COST

Agency	Maintenance Cost (per km)	Total Project Cost (per km)	Percentage (%)
ETA	924,000 Baht	250 million Baht	0.37
JHPC	28,000,000 Yen	4,400 million Yen	0.64
Average			0.505

By applying the average value in Table 10.7, the maintenance for the proposed toll motorways is computed as follows:

$$\text{Maintenance cost/year/km} = 81.9 \text{ million Baht/km} \times 0.505\%$$
$$\fallingdotseq @\ 400{,}000 \text{ Baht}$$

This amount is almost the same as the cost estimated through the breakdown. Therefore, 400,000 Baht/year/km is adopted as the maintenance cost in the study.

2) Operation Cost

As mentioned previously, the operation cost consists of three costs: operation office cost, toll collection cost and traffic control cost.

a. Operation Office Cost

The operation office cost is calculated based on remuneration of staff assigned in the operation office. This is estimated as shown in Table 10.8.

Table 10.8 COST OF ONE OPERATION OFFICE (Baht/year)

Profession	Number	Remuneration /year	Total
Chief	1	144,000 (12,000)	144,000
Assistant Chief	3	108,000 (9,000)	324,000
Staff	30	60,000 (5,000)	1,800,000
Car Driver	10	49,200 (4,100)	492,000
Road Worker	20	39,600 (3,300)	792,000
Total			3,552,000

( ): Monthly remuneration

As mentioned in Chapter 9, an operation office covers a 50 km section of the motorway. Therefore, the operation office cost/year/km is calculated as follows:

3,552,000 Baht/year ÷ 50.0 km = 71,040 Baht/year/km

b. Toll Collection Cost

The toll collection cost is also estimated based on remuneration of staff assigned in the toll collection office. This is estimated as shown in Table 10.9.

As mentioned in Chapter 9, 146 toll collection offices are planned for the whole motorway network of 4,300 km in total. The toll collection cost/km/year is calculated as follows:

3,765,600 Baht/year/office × 146 offices ÷ 4,300 km
= 127,855 Baht/year/km

Table 10.9 COST OF ONE TOLL COLLECTION OFFICE (Baht/year)

Profession	Number	Remuneration /year	Total
Chief	1	144,000 (12,000)	144,000
Manager	3	108,000 (9,000)	324,000
Toll Collector	60	49,200 (4,100)	2,952,000
Car Driver	3	49,200 (4,100)	147,600
Road Worker	5	39,600 (3,300)	198,000
Total			3,765,600

( ): Monthly remuneration

c. Traffic Control Cost

The traffic control cost is estimated on the assumption that this work will be carried out under contract base. Estimated unit costs of the traffic control work are shown in Table 10.10.

Table 10.10 UNIT COST OF TRAFFIC CONTROL WORK (Baht/year/km)

Work Item	Cost
Road Patrol	40,000
Operation of Monitoring System	30,000
Equipment Maintenance (including repair and improvement)	50,000
Traffic Regulation	20,000
Treatment of Traffic Accident	20,000
Total	160,000

d. Total Operation Cost

A total unit cost of the operation work is calculated as follows:

(1)	Operation office cost	= 71,040	
(2)	Toll collection cost	= 127,855	
(3)	Traffic control cost	= 160,000	
(4)	Indirect cost = [(1) + (2) + (3)] x 10%	= 35,890	
(5)	Administration cost	= 95,276	(see section of maintenance cost)
	Total	490,061	Baht/year/km

From Table 10.6, the toll operation cost including administration cost of ETA in 1988 is estimated as 38.406 million Baht for ETA network on the same assumptions as mentioned previously. This is 1,423,000 Baht per kilometer length. On the other hand, and according to the "Expressway Handbook - JHPC", the toll operation cost including overhead in 1988 is 32,700,000 Yen/Km (6,540,000 Baht/km). The cost of JHPC is about 5 times higher than that of ETA.

The operation costs is also considered to be in similar proportion to the total project cost regardless any variety in conditions. Table 10.11 shows percentages of the toll operation costs to the total project costs for ETA and JHPC.

Table 10.11 PERCENTAGE OF TOLL OPERATION COST TO TOTAL PROJECT COST

Agency	Operation Cost (Per Km)	Total Project Cost (Per Km)	Percentage (%)
ETA	1,423,000 Baht	250 million Baht	0.56
JHPC	32,700,000 Yen	4,400 million Yen	0.74
Average			0.65

In the same procedure as the case of the maintenance cost, the toll operation cost for the proposed toll motorways can be estimated as follows:

Toll operation cost/km/year = 81.9 million Baht/km × 0.65 %
= @ 500,000 Baht

This amount is almost the same as the cost estimated through the breakdown. Therefore, 500,000 Baht/year/km is adopted as the operation cost in the Study.

10.3 BENEFIT

10.3.1 Classification of Benefit of Motorways

Benefits which are expected from a road construction project can be classified usually into the following two types:

1) Direct Benefit
2) Indirect Benefit (Regional Development Effects)

Direct benefit is enjoyed by road users who directly use the motorways. Indirect benefit is induced by direct benefit and realized as regional development effects.

In this section, some portions of direct benefit is estimated quantitatively at first, and then explanations of indirect benefit are presented.

10.3.2 Direct Benefit

1) Procedure for Benefit Calculation

The economic direct benefits of motorways are calculated as savings in Vehicle Operating Cost (VOC) and savings in Travel Time Cost through a "With Project" and "Without Project" comparison scenario.

There are two types of traffic forecasted in Chapter 6 which are: "normal traffic" and "induced traffic". Benefits of normal traffic can be estimated by applying the above scenario, but benefits of induced traffic can not be estimated by the same method because they do not exist in the "Without Project" case.

An alternative procedure for the benefit calculation of induced traffic is to apply the so-called "1/2 rule", i.e., half of the unit benefit of normal traffic is applied to induced traffic.

2) Vehicle Operating Cost (VOC)

A number of feasibility studies have been conducted in

Thailand, through which a generalized methodology has been established by DOH for determining vehicle operating cost (Standardization of Vehicle Operating Cost in Thailand: SVOCT). Recent studies (*) done through SVOCT are updated to convert 1988 price data into 1990 price level.

(*): 1. "Study Report (Vehicle Operating Cost)" Programming Section, Planning Division, DOH, Nov. 1988.

2. "Road Development Study in the Central Region" Feasibility Study, Final Report, JICA, March 1989.

a. Components of VOC

VOC consists of the following components:

- Fuel cost
- Oil cost
- Tire cost
- Maintenance cost
- Capital cost
- Overhead cost
- Crew cost

b. Road Classification

Unit costs of vehicle operation are estimated for level tangent roads by road condition such as paved or laterite, good or poor. The following road classification is adopted in this study:

Classification	Surface Condition
Paved Road	Good Good/Fair Fair Fair/Poor Poor
Laterite Road	Good Fair Poor

c. Typical Vehicles

The classification of vehicle types for VOC estimation is decided according to the vehicle types adopted in the future traffic demand forecasting. They are passenger car (PC), light bus (LB), medium bus (MB), heavy bus (HB), pick-up for passengers (PP), light truck (LT), medium truck (MT) and heavy truck (HT). The characteristics of presented vehicles by each type are shown in Table 10.12.

Table 10.12 CHARACTERISTICS OF TYPICAL VEHICLES

Vehicle Type	Typical Vehicle	No. of Tires	Selling Price (Baht)
PC	Toyota Corona (1600cc)	4	526,000*
LB	Toyota Hilux	4	313,000*
MB	Isuzu MPR59LU	6	532,600
HB	Hino AK	6	1,400,000
PP	Toyota Hilux SR5 2400cc	4	309,000*
LT	Isuzu Faster-Z 2500cc	4	295,800*
MT	Isuzu MPR59LU	6	510,000
HT	Hino FM176	10	1,070,000

Source : * Car Magazine, Oct. 1990.
The Survey of Urban Transport Cost and Fares in SEATAC Region, Phase I, Draft Final Report, Aug. 1990.

d. Fuel Cost

The prices of petrol and diesel in 1990 are obtained including the taxes, duties and oil fund as shown in Table 10.13.

The average economic costs of premium petrol, regular petrol and diesel are calculated at 8.28, 7.83, 7.41 Baht per liter, respectively, as shown in Table 10.14. The fuel costs, including average financial and economic transport costs of 0.21 and 0.16 Baht, respectively, per liter for 250 km transportation, are presented in Table 10.15.

Table 10.13 FUEL COST

(Baht/liter)

Price & Taxes \ Fuel Type		Premium Petrol Locally Refined	Premium Petrol Imported	Regular Petrol Locally Refined	Regular Petrol Imported	High-Speed Diesel Locally Refined	High-Speed Diesel Imported
Economic Cost	Ex-refi-neryPrice	7.6599	-	7.2507	-	7.4179	-
	Imported Price	-	7.6599	-	7.2507	-	6.0110
	Market Margin	0.6220	0.6220	0.5809	0.5809	0.4858	0.4858
	Sub-total	8.2819	8.2819	7.8316	7.8316	7.9037	6.4968
Taxes	Import Duty	-	0.0100	-	0.0100	-	0.0100
	Business & Munici-pal Taxes	3.4340	3.4340	3.4340	3.4340	1.9190	1.9190
	Oil Fund	-0.6659	-0.6759	-0.9156	-0.9256	-1.4227	-0.0258
Retail Price		11.0500	11.0500	10.3500	10.3500	8.4000	8.4000
Share in the Thai market (%)		76%	24 %	76 %	24 %	65 %	35 %

Source : Fiscal Policy Office, Ministry of Finance
Oct, 1990

Table 10.14 AVERAGE COST OF FUEL (Baht/liter)

Fuel Type	Share (%)	Financial Cost	Economic Cost
PREMIUM PETROL			
Locally Refined	76	11.05	8.2819
Imported	24	11.05	8.2819
Average Price		11.05	8.2819
REGULAR PETROL			
Locally Refined	76	10.35	7.8316
Imported	24	10.35	7.8316
Average Price		10.35	7.8316
HIGH-SPEED DIESEL			
Locally Refined	65	8.40	7.9037
Imported	35	8.40	6.4968
Average Price		8.40	7.4113

Table 10.15 ECONOMIC AND FINANCIAL COSTS OF FUEL (Baht/liter)

Type of Fuel	Financial Cost	Economic Cost
Premium Petrol	11.26	8.44
Regular Petrol	10.56	7.99
High-speed Diesel	8.61	7.57

The fuel costs by vehicle type are calculated as shown in Table 10.16 by applying the usage composition of fuel types presented in Table 10.17.

Table 10.16 FUEL COST BY VEHICLE TYPE (Baht/liter)

Vehicle Type	Financial Cost	Economic Cost
Passenger Car (PC)	10.82	8.24
Light Bus (LB)	9.07	7.70
Medium Bus (MB)	8.61	7.57
Heavy Bus (HB)	8.61	7.57
Pickup Passengers (PP)	9.07	7.70
Light Truck (LT)	9.07	7.70
Medium Truck (MT)	8.61	7.57
Heavy Truck (HT)	8.61	7.57

Table 10.17 USAGE OF FUEL BY VEHICLE TYPE (%)

Vehicle Type	Premium Petrol	Regular Petrol	High-Speed Diesel
PC	65	25	10
LB	10	10	80
LT	10	10	80
MB, HB	-	-	100
MT, HT	-	-	100
PP	10	10	80

Fuel consumption rates by speed on paved road (good condition), laterite road (good condition) and laterite road (poor condition) have been prepared by DOH. The study team adopted these rates after supplemented the information on the speed ranks from 90 km/hour to 120 km/hour by referring to experienced data in Japan. The applied fuel consumption rates are shown in Table 10.18, and the economic fuel costs by speed are presented in Table 10.19.

Table 10.18 VARIATION IN FUEL CONSUMPTION (liter/1000km)

Speed	PC	LB	MB	HB	PP	LT	MT	HT
Paved Road (Good Condition)								
20	138.0	156.0	197.0	311.2	156.0	156.0	197.0	342.3
30	108.1	122.2	160.4	284.2	122.2	122.2	160.4	312.6
40	95.5	107.9	147.8	264.5	107.9	107.9	147.8	290.9
50	89.7	101.4	160.4	284.2	101.4	101.4	160.4	312.6
60	86.2	97.5	178.0	326.1	97.5	97.5	178.0	358.6
70	85.4	98.2	202.6	380.9	98.2	98.2	202.6	418.9
80	88.6	102.0	243.9	438.1	102.0	102.0	243.9	481.8
90	94.3	107.2	280.0	500.0	107.2	107.2	280.0	550.0
100	115.0	140.0	320.0	561.8	140.0	140.0	320.0	618.0
110	142.2	173.1	395.7	694.7	173.1	173.1	395.7	764.2
120	204.0	248.3	567.7	996.6	248.3	248.3	567.7	1096.3
Laterite Road (Good Condition)								
20	151.8	174.7	234.4	371.8	174.7	174.7	234.4	410.7
30	118.9	138.0	190.9	339.6	138.0	138.0	190.9	375.1
40	105.0	122.3	175.8	316.1	122.3	122.3	175.8	345.5
50	98.2	114.6	190.9	339.6	114.6	114.6	190.9	372.0
60	97.4	110.1	213.6	391.3	110.1	110.1	213.6	430.3
70	98.2	112.9	243.2	457.1	112.9	112.9	243.2	506.7
80	101.9	117.3	292.8	525.7	117.3	117.3	292.8	582.8
Laterite Road (Poor Condition)								
20	163.3	199.6	267.9	420.1	199.6	199.6	267.9	465.5
30	130.8	157.3	218.2	386.5	157.3	157.3	218.2	421.9
40	116.5	139.2	204.0	365.0	139.2	139.2	204.0	391.9
50	112.1	131.8	224.5	395.0	131.8	131.8	224.5	425.1

Table 10.19 ECONOMIC FUEL COST BY SPEED (Baht/km)

Speed	PC	LB	MB	HB	PP	LT	MT	HT
Paved Road (Good Condition)								
20	1.137	1.201	1.492	2.356	1.201	1.201	1.492	2.592
30	0.891	0.941	1.214	2.152	0.941	0.941	1.214	2.367
40	0.787	0.831	1.119	2.003	0.831	0.831	1.119	2.202
50	0.739	0.781	1.214	2.152	0.781	0.781	1.214	2.367
60	0.710	0.751	1.348	2.469	0.751	0.751	1.348	2.715
70	0.704	0.756	1.534	2.884	0.756	0.756	1.534	3.172
80	0.730	0.785	1.847	3.317	0.785	0.785	1.847	3.648
90	0.777	0.825	2.120	3.786	0.825	0.825	2.120	4.164
100	0.948	1.078	2.423	4.254	1.078	1.078	2.423	4.679
110	1.172	1.333	2.996	5.260	1.333	1.333	2.996	5.786
120	1.681	1.912	4.298	7.546	1.912	1.912	4.298	8.300
Laterite Road (Good Condition)								
20	1.251	1.345	1.775	2.815	1.345	1.345	1.775	3.110
30	0.980	1.063	1.445	2.571	1.063	1.063	1.445	2.840
40	0.865	0.942	1.331	2.393	0.942	0.942	1.331	2.616
50	0.809	0.882	1.445	2.571	0.882	0.882	1.445	2.817
60	0.803	0.848	1.617	2.963	0.848	0.848	1.617	3.258
70	0.809	0.869	1.841	3.461	0.869	0.869	1.841	3.836
80	0.840	0.903	2.217	3.980	0.903	0.903	2.217	4.413
Laterite Road (Poor Condition)								
20	1.346	1.537	2.028	3.181	1.537	1.537	2.028	3.524
30	1.078	1.211	1.652	2.926	1.211	1.211	1.652	3.194
40	0.960	1.072	1.545	2.764	1.072	1.072	1.545	2.967
50	0.924	1.015	1.700	2.991	1.015	1.015	1.700	3.219

e. Oil Cost

The prices of motor oil for petrol- and diesel-vehicles are shown in Table 10. 20. Economic oil cost by vehicle type is calculated based on the percentage shares of each kind of fuel used for each vehicle type as listed in Table 10.21.

Table 10.20 OIL COST (Baht/liter)

Type of Oil	Selling Price	Duty & Taxes	Economic Cost
Oil for Petrol-Vehicles	52.00	9.90	42.10
Oil for Diesel-Vehicles	43.00	9.03	33.97

Source : Price at gas stations, October, 1990.

Table 10.21 OIL COST BY VEHICLE TYPE (Baht/liter)

Vehicle Type	Retail Price	Taxes	Economic Cost
PC	51,10	9.81	41.29
LB, PP	44.80	9.20	35.60
LT	44.80	9.20	35.60
MB, MT	43.00	9.03	33.97
HB, HT			

Source : Price at gas stations, October, 1990.

Oil consumption rates by road type which have been adopted as DOH's standards are presented in Table 10. 22. These rates are also applied to the above oil costs. The economic oil costs by road type and by speed are calculated as shown in Table 10. 23.

Table 10.22 OIL CONSUMPTION BY ROAD TYPE (liter/1000km)

Road Type	PC	LB, LT, PP	MT	HB & HT
Paved (Good)	0.5	0.7	1.4	2.0
Laterite (Good)	0.6	1.0	1.9	2.6
Laterite (Poor)	1.0	1.4	2.7	4.0

Table 10.23 ECONOMIC OIL COST BY ROAD TYPE (Baht/km)

Road Type	PC	LB	MB	HB	PP	LT	MT	HT
Paved Road (Good)	0.021	0.025	0.048	0.068	0.025	0.025	0.048	0.068
Laterite Road (Good)	0.025	0.036	0.065	0.088	0.036	0.036	0.065	0.088
Laterite Road (Poor)	0.041	0.050	0.092	0.136	0.050	0.050	0.092	0.136

f. Tire Cost

Unit prices of tires are surveyed by DOH, and the results are summarized in Table 10.24.

Table 10.24 COST OF TIRES (Baht)

Vehicle Type	Single Tire				Set of Tires		
	List-Price	Typical Discount(%)	Av. Price Selling	Tax	Selling Price/Set	Tax Per Set	Economic Cost
PC	1,170	25	878	140	3,512 (4,390)	560 (700)	2,952 (3,690)
LB	1,410	25	1,058	174	4,232 (5,290)	696 (870)	3,536 (4,420)
MB	3,460	25	2,595	423	15,570 (18,165)	2,538 (2,961)	13,032 (15,204)
HB	7,180	25	5,385	881	32,310 (37,695)	5,286 (6,167)	27,024 (31,528)
PP	1,410	25	1,058	174	4,232 (5,290)	696 (870)	3,536 (4,420)
LT	1,410	25	1,058	174	4,232 (5,290)	696 (870)	3,536 (4,420)
MT	3,460	25	2,595	423	15,570 (18,165)	2,538 (2,961)	13,032 (15,204)
HT	5,170	25	3,878	635	38,780 (42,658)	6,350 (6,985)	32,430 (35,673)

Note: Figures in brackets ( ) indicate the costs of a set of tires including spare.

The tire consumption rates currently adopted by DOH are as shown in Table 10.25. The economic tire costs by speed are calculated by combining the tire costs with the tire consumption rates and the results are presented in Table 10.26.

Table 10.25 TIRE CONSUMPTION BY ROAD TYPE

Road Type	PC	LB, LT, PP	MT	HB	HT
Tire life (kilometer):					
Paved (Good)	45,000	45,000	45,000	50,000	55,000
Laterite (Good)	28,000	28,000	28,000	31,000	33,900
Laterite (Poor)	13,000	13,000	13,000	14,000	15,600
Tire consumption (tire per 1000 km):					
Paved (Good)	0.089	0.089	0.133	0.120	0.182
Laterite (Good)	0.143	0.143	0.214	0.194	0.295
Laterite (Poor)	0.308	0.308	0.462	0.429	0.641

Table 10.26 ECONOMIC TIRE COST BY ROAD TYPE (Baht/km)

Road Type	PC	LB	MB	HB	PP	LT	MT	HT
Paved Road (Good)	0.066	0.079	0.290	0.540	0.079	0.079	0.290	0.590
Laterite Road (Good)	0.105	0.126	0.465	0.872	0.126	0.126	0.465	0.957
Laterite Road (Poor)	0.227	0.272	1.002	1.930	0.272	0.272	1.002	2.079

g. Maintenance Cost

Economic vehicle maintenance cost is updated by applying price escalation rate from 1988 to 1990 (4.9 % per annum) to the 1988 data surveyed by DOH, and revised values are shown in Table 10.27.

Table 10.27 MONTHLY MAINTENANCE COSTS (Baht/month)

Vehicle Type	Financial Cost	Economic Cost
PC	1,210	990
LB	1,160	970
MB	2,860	2,310
HB	10,120	8,470
PP	1,160	970
LT	1,160	970
MT	2,860	2,310
HT	5,060	4,180

The above values are converted into the economic maintenance costs per kilometrage based on the data on annual kilometrage at average speeds by road type shown in Table 10.28. Calculated maintenance costs by road type are presented in Table 10.29.

Table 10.28 ANNUAL KILOMETRAGE AND AVERAGE SPEED BY ROAD TYPE

Vehicle Type	Paved Road (Good Condition)		Laterite Road (Good Condition)		Laterite Road (Poor Condition)	
	Annual km	Average Speed	Annual km	Average Speed	Annual km	Average Speed
PC	23,000	70	20,000	50	16,250	25
LB	34,000	60	31,800	50	27,400	30
MB	40,000	60	37,800	50	33,400	30
HB	100,000	60	94,000	50	60,000	30
PP	34,000	60	31,800	50	27,400	30
LT	30,000	60	28,000	50	24,000	30
MT	40,000	60	36,700	45	33,400	30
HT	75,000	60	67,500	45	60,000	30

Table 10.29 ECONOMIC MAINTENANCE COST BY ROAD TYPE (Baht/km)

Road Type	PC	LB	MB	HB	PP	LT	MT	HT
Paved Road (Good)	0.517	0.342	0.693	1.016	0.342	0.388	0.693	0.669
Laterite Road (Good)	0.594	0.366	0.733	1.081	0.366	0.416	0.755	0.743
Laterite Road (Poor)	0.731	0.425	0.830	1.694	0.425	0.485	0.830	0.836

h. Capital Cost

The annual capital costs of typical vehicles are calculated based on the following formula:

$$A = (P-L) * CRF + L * i$$

where,
- A : Annual capital cost
- P : Economic value of vehicle
- L : Salvage value of vehicle
- i : Annual rate of interest, 12 %
- CRF : Capital Recovery Factor

$$CRF = [i * (1 + i)^n]/[(1 + i)^n - 1]$$

where, n : Vehicle life in years

Economic values, salvage values, vehicle life, annual kilometrage and annualized economic capital costs of typical vehicles are presented in Appendix 10.5. The results of the calculation are shown in Table 10.30.

Table 10.30 VARIATION IN ECONOMIC CAPITAL COST AT DIFFERENT SPEEDS (Baht/km)

Speed	PC	LB	MB	HB	PP	LT	MT	HT
Paved Road (Good)								
20	2.237	1.501	2.111	2.284	1.481	1.706	2.019	2.367
30	2.066	1.400	1.992	2.141	1.382	1.587	1.905	2.198
40	1.920	1.312	1.887	2.015	1.295	1.484	1.804	2.053
50	1.794	1.235	1.792	1.904	1.219	1.394	1.714	1.927
60	1.685	1.168	1.707	1.806	1.152	1.315	1.632	1.816
70	1.589	1.107	1.630	1.718	1.093	1.245	1.559	1.718
80	1.503	1.053	1.560	1.637	1.039	1.182	1.492	1.630
90	1.427	1.004	1.496	1.564	0.991	1.126	1.430	1.550
100	1.358	0.959	1.436	1.496	0.947	1.075	1.374	1.478
110	1.295	0.919	1.382	1.434	0.907	1.027	1.321	1.413
120	1.238	0.883	1.330	1.418	0.871	1.024	1.272	1.353
Laterite Road (Good)								
20	2.645	1.739	2.475	2.661	1.717	1.977	2.367	2.778
30	2.453	1.627	2.341	2.503	1.606	1.846	2.239	2.588
40	2.290	1.530	2.223	2.364	1.510	1.730	2.126	2.425
50	2.147	1.444	2.117	2.239	1.425	1.630	2.024	2.283
60	2.022	1.367	2.020	2.128	1.349	1.542	1.932	2.156
70	1.911	1.299	1.932	2.028	1.282	1.462	1.847	2.043
80	1.812	1.237	1.852	1.936	1.221	1.390	1.771	1.943
Laterite Road (Poor)								
20	3.658	2.510	3.290	3.565	2.477	2.858	3.147	3.707
30	3.408	2.358	3.122	3.364	2.328	2.677	2.986	3.467
40	3.187	2.222	2.970	3.185	2.193	2.519	2.840	3,256
50	2.995	2.103	2.834	3.025	2.076	2.378	2.710	3.049

i. Overhead Cost

Annual overhead costs are updated by applying the same price escalation rate as adopted in the revision of maintenance costs to the previous results of DOH's survey conducted in 1988. Revised annual overhead costs are shown in Table 10.31.

Table 10.31 ANNUAL OVERHEAD COST (Baht/year)

	LB	MB	HB	PP	LT	MT	HT
Financial	3,410	16,280	52,800	3,410	3,410	9,570	47,630
Economical	2,970	14,190	46,530	2,970	2,970	8,360	41,800

Economic overhead costs by speed are calculated by applying annual kilometrage to the above values and the results are shown in Table 10.32.

Table 10.32 VARIATION IN OVERHEAD COST AT DIFFERENT SPEEDS (Baht/km)

Speed	LB	MB	HB	PP	LT	MT	HT
Paved Road (Good)							
20	0.118	0.455	0.612	0.118	0.135	0.268	0.760
30	0.108	0.425	0.567	0.108	0.124	0.250	0.697
40	0.100	0.399	0.529	0.100	0.114	0.235	0.643
50	0.093	0.375	0.495	0.093	0.106	0.221	0.597
60	0.087	0.355	0.465	0.087	0.099	0.209	0.557
70	0.082	0.336	0.439	0.082	0.093	0.198	0.523
80	0.077	0.320	0.415	0.077	0.087	0.188	0.492
90	0.073	0.305	0.394	0.073	0.083	0.179	0.464
100	0.069	0.291	0.375	0.069	0.078	0.171	0.440
110	0.066	0.278	0.358	0.066	0.074	0.164	0.418
120	0.063	0.267	0.342	0.063	0.071	0.157	0.398
Laterite Road (Good)							
20	0.118	0.455	0.612	0.118	0.135	0.268	0.760
30	0.108	0.425	0.567	0.108	0.124	0.250	0.697
40	0.100	0.399	0.529	0.100	0.114	0.235	0.643
50	0.093	0.375	0.495	0.093	0.106	0.221	0.597
60	0.087	0.355	0.465	0.087	0.099	0.209	0.557
70	0.082	0.336	0.439	0.082	0.093	0.198	0.523
80	0.077	0.320	0.415	0.077	0.087	0.188	0.492
Laterite Road (Poor)							
20	0.118	0.455	0.612	0.118	0.135	0.268	0.760
30	0.108	0.425	0.567	0.108	0.124	0.250	0.697
40	0.100	0.399	0.529	0.100	0.114	0.235	0.643
50	0.093	0.375	0.495	0.093	0.106	0.221	0.597

j. Crew Cost

Crew salaries and allowances are included in vehicle operating costs as crew costs for commercial vehicles. DOH has collected salary data in the previous survey and, this time, DOH and the study team jointly interviewed agencies concerned to update the salaries of drivers and assistants. However, it seemed to be difficult to keep consistency between the previous results and newly collected data. It is decided, therefore, to apply growth rate of Per Capita GDP to the 1988 salary data as an alternative method.

Growth rate of Per Capita GDP = 1.218
(in current price 1988-1990)

Revised unit salary and allowance costs are shown below:

(Baht/month)

Vehicle Type	Driver Salary	Driver Allowance	No.of Assistants	Assistant Salary
LB	4,100	-	-	-
HB	5,100	2,900	2	3,300*2
MT	3,700	1,500	1	2,600
HT	4,600	2,400	2	2,600*2

Financial and economic costs of the annual crew salaries and allowances after applying the shadow wage rates are shown in Appendix 10.6, and the variation in economic costs in Table 10.33.

Table 10.33 VARIATION IN ECONOMIC CREW COSTS (Baht/km)

Speed	LB	MB	HB	PP	LT	MT	HT
Paved Road (Good)							
20	1.365	2.587	1.808	1.365	1.564	2.314	2.004
30	1.255	2.416	1.676	1.255	1.433	2.162	1.837
40	1.162	2.267	1.561	1.162	1.323	2.028	1.695
50	1.082	2.135	1.462	1.082	1.229	1.910	1.574
60	1.012	2.018	1.374	1.012	1.147	1.805	1.469
70	0.950	1.912	1.296	0.950	1.075	1.711	1.378
80	0.896	1.818	1.227	0.896	1.012	1.626	1.296
90	0.847	1.732	1.164	0.847	0.956	1.549	1.224
100	0.804	1.654	1.108	0.804	0.905	1.480	1.160
110	0.764	1.582	1.057	0.764	0.860	1.416	1.102
120	0.729	1.517	1.010	0.729	0.819	1.357	1.050
Laterite Road (Good)							
20	1.365	2.587	1.808	1.365	1.564	2.314	2.004
30	1.255	2.416	1.676	1.255	1.433	2.162	1.837
40	1.162	2.267	1.561	1.162	1.323	2.028	1.695
50	1.082	2.135	1.462	1.082	1.229	1.910	1.574
60	1.012	2.018	1.374	1.012	1.147	1.805	1.469
70	0.950	1.912	1.296	0.950	1.075	1.711	1.378
80	0.896	1.818	1.227	0.896	1.012	1.626	1.296
Laterite Road (Poor)							
20	1.365	2.587	1.808	1.365	1.564	2.314	2.004
30	1.255	2.416	1.676	1.255	1.433	2.162	1.837
40	1.162	2.267	1.561	1.162	1.323	2.028	1.695
50	1.082	2.135	1.462	1.082	1.229	1.910	1.574

k. Cost Variation by Road Condition

In the above estimation of VOC, the basic operating costs of vehicles on paved good condition roads (RC1), laterite good and poor condition roads (RC4 and RC7) are established at 1990 price level. VOC of other road conditions such as paved good/fair, paved fair, paved poor and laterite fair are calculated by means of interpolation as shown below:

```
Paved good/fair (RC2) = RC1 + 1/3 (RC4 - RC1)
Paved fair      (RC3) = RC1 + 2/3 (RC4 - RC1)
Paved poor      (RC5) = RC4 + 1/2 (RC4 - RC1)
Laterite fair   (RC6) = RC4 + 1/3 (RC7 - RC4)
```

The vehicle operating costs for each road type are shown in Table 10.34.

Table 10.34 ECONOMIC VEHICLE OPERATING COSTS (1/3) (Baht/km)

	Speed	Road Condition						
		RC1	RC2	RC3	RC4	RC5	RC6	RC7
PC	20	3.977	4.191	4.406	4.620	4.942	5.081	6.003
	30	3.559	3.759	3.958	4.158	4.457	4.600	5.485
	40	3.310	3.500	3.690	3.879	4.164	4.302	5.147
	50	3.137	3.318	3.499	3.680	3.952	4.093	4.919
	60	2.998	3.182	3.365	3.549	3.824		
	70	2.895	3.078	3.261	3.444	3.719		
	80	2.836	3.016	3.196	3.376	3.646		
	90	2.807						
	100	2.908						
	110	3.070						
	120	3.522						
LB	20	4.631	4.786	4.941	5.095	5.328	5.489	6.276
	30	4.150	4.294	4.438	4.582	4.798	4.948	5.680
	40	3.851	3.988	4.125	4.262	4.468	4.609	5.303
	50	3.637	3.768	3.899	4.030	4.226	4.366	5.040
	60	3.463	3.590	3.716	3.842	4.031		
	70	3.341	3.470	3.599	3.728	3.922		
	80	3.257	3.385	3.514	3.642	3.834		
	90	3.195						
	100	3.356						
	110	3.528						
	120	4.032						
MB	20	7.674	7.968	8.261	8.554	8.994	9.131	10.284
	30	7.078	7.349	7.620	7.891	8.298	8.440	9.539
	40	6.701	6.962	7.223	7.483	7,874	8.023	9.104
	50	6.547	6.810	7.073	7.336	7.730	7.880	8.968
	60	6.457	6.729	7.001	7.273	7.681		
	70	6.443	6.723	7.004	7.285	7.706		
	80	6.574	6.872	7.171	7.469	7.916		
	90	6.682						
	100	6.834						
	110	7.268						
	120	8.442						

Table 10.34 ECONOMIC VEHICLE OPERATING COSTS (2/3) (Baht/km)

	Speed	Road Condition						
		RC1	RC2	RC3	RC4	RC5	RC6	RC7
HB	20	8.685	9.103	9.520	9.938	10.564	10.934	12.926
	30	8.160	8.560	8.959	9.358	9.958	10.337	12.293
	40	7.733	8.118	8.503	8.889	9.467	9.859	11.799
	50	7.638	8.028	8.418	8.808	9.394	9.783	11.732
	60	7.739	8.150	8.560	8.971	9.587		
	70	7.961	8.396	8.831	9.265	9.917		
	80	8.221	8.681	9.141	9.600	10.290		
	90	8.533						
	100	8.858						
	110	9.733						
	120	11.940						
PP	20	4.611	4.765	4.919	5.073	5.304	5.463	6.244
	30	4.132	4.275	4.418	4.561	4.775	4.924	5.649
	40	3.834	3.970	4.106	4.242	4.446	4.586	5.274
	50	3.621	3.751	3.881	4.011	4.206	4.345	5.013
	60	3.448	3.574	3.699	3.824	4.012		
	70	3.327	3.455	3.583	3.711	3.904		
	80	3.243	3.371	3.498	3.626	3.817		
	90	3.182						
	100	3.344						
	110	3.516						
	120	4.021						
LT	20	5.097	5.264	5.431	5.598	5.849	6.033	6.901
	30	4.576	4.732	4.888	5.043	5.277	5.446	6.252
	40	4.244	4.391	4.539	4.687	4.909	5.070	5.835
	50	4.001	4.142	4.284	4.425	4.637	4.795	5.535
	60	3.803	3.940	4.076	4.213	4.417		
	70	3.661	3.799	3.938	4.076	4.284		
	80	3.558	3.696	3.833	3.970	4.176		
	90	3.481						
	100	3.628						
	110	3.786						
	120	4.317						
MT	20	7.123	7.418	7.713	8.009	8.452	8.566	9.681
	30	6.562	6.835	7.108	7.382	7.792	7.912	8.974
	40	6.216	6.479	6.742	7.005	7.400	7.528	8.572
	50	6.090	6.355	6.621	6.886	7.284	7.412	8.465
	60	6.024	6.299	6.574	6.848	7.260		
	70	6.032	6.315	6.599	6.883	7.309		
	80	6.183	6.484	6.786	7.087	7.539		
	90	6.309						
	100	6.478						
	110	6.927						
	120	8.115						

Table 10.34 ECONOMIC VEHICLE OPERATING COSTS (3/3) (Baht/km)

	Speed	Road Condition						
		RC1	RC2	RC3	RC4	RC5	RC6	RC7
HT	20	9.049	9.512	9.976	10.439	11.134	11.308	13.046
	30	8.425	8.866	9.308	9.750	10.412	10.581	12.245
	40	7.920	8.336	8.752	9.167	9.791	9.982	11.612
	50	7.791	8.214	8.636	9.059	9.693	9.869	11.489
	60	7.884	8.332	8.780	9.228	9.901		
	70	8.116	8.600	9.084	9.568	10.294		
	80	8.392	8.905	9.418	9.931	10.700		
	90	8.730						
	100	9.084						
	110	10.045						
	120	12.427						
MB+HB	20	8.537	8.937	9.336	9.736	10.335	10.671	12.540
	30	8.002	8.383	8.764	9.144	9.715	10.060	11.891
	40	7.582	7.949	8.316	8.683	9.234	9.591	11.406
	50	7.478	7.850	8.222	8.593	9.151	9.505	11.329
	60	7.552	7.942	8.333	8.723	9.309		
	70	7.740	8.152	8.564	8.976	9.594		
	80	7.981	8.417	8.853	9.289	9.943		
	90	8.263						
	100	8.563						
	110	9.373						
	120	11.430						

3) Time Value of Passengers

Savings in time cost of passenger movement are measured in terms of money and quantified in economic evaluation. The time costs of drivers and assistants are reflected in VOC estimation as crew costs. Only the time values of passengers, therefore, are calculated here to avoid double counting. The following factors should be taken into account for the estimation of time values:

a. Average wage rates of car-owning group and non-car owning group.
b. Working hours.
c. Trip purpose composition (business and others).
d. Differences in time values between business trip and other trip purposes.
e. Average occupancy by passenger vehicle type.

The average time values of passengers for business trips are updated by applying the growth rate of Per Capita GDP (= 1.218 :1990/1988) to the results of previous study (Road Development

Study in the Central Region, JICA, 1989), and shown in Table 10.35.

Table 10.35 TIME VALUES OF PASSENGERS FOR BUSINESS TRIPS

Vehicle Type	Monthly Wages (Baht)	Working Hour (Hr/mth.)	Value of Time (Baht/hr)
PC	7,360	185	39.8
LB	3.030	200	15.2
MB	3,030	200	15.2
HB	3,030	200	15.2
PP	3,030	200	15.2

The time values of non-business trips are assumed to be at 25 % of the time values of business trips according to the same method adopted in the previous study, which result in the value of 5.02 Baht per hour. Average occupancy and percentage of business trips by vehicle type are shown in Table 10.36. Applying these data, time values by vehicle type are estimated as shown in Table 10.37.

Table 10.36 AVERAGE OCCUPANCY AND SHARE OF BUSINESS TRIPS

Vehicle Type	Number of Persons*	Business Trips (%)
PC	2.8	39.0
LB	6.4	37.7
MB	17.4	32.0
HB	37.7	35.9
PP	2.4	37.7

Source: OD Survey by the study team, 1990.
The shares of business trip by buses and PP are assumed to be the same as the Road Development Study in the Central Region, JICA, 1989.
Note: * Excluding drivers and assistants of LB, MB, HB and PP.

Table 10.37 TIME VALUES OF PASSENGERS (In 1990 price)

Vehicle Type	Number of Perons (A)	Business Trip Ratio (B)	Values of Time for Business Trips (C)	Values of Time for Other Trips (D)	Time Values (Baht/hour) Business Trips (E)=(A)*(B)/100 (C)	Other Trips (F)=(A)*(100-B)/100*(D)	Total
PC	2.8	39.0	39.8	5.02	43.5	8.6	52.0
LB	6.4	37.7	15.2	5.02	36.7	20.0	56.7
MB	17.4	32.0	15.2	5.02	84.6	59.4	144.0
HB	37.7	35.9	15.2	5.02	205.7	121.3	327.0
PP	2.4	37.7	15.2	5.02	13.8	7.5	21.3

4) Alternative Staging Plans for Evaluation

Economic evaluation (and financial evaluation as well) for the proposed network is required to investigate the economical feasibility of the whole network of motorways. The network, however, consists of 14 (fourteen) routes of which the total length attains to about 4,300 km.

The main issue in evaluating such a big project is that the implementation should be started from which route and from which part of the network.

Therefore, the following 3 (three) scenarios are prepared for the first 5 years (1991-1995).

Scenario — 1: Traffic Volume Criterion
- To give high priority to sections with high traffic volume to start early implementation.
- To connect regions with Bangkok and form a network for the Eastern Sea Board.
- To construct motorways around major local cities for regional development.

Scenario — 2: Bangkok Metropolitan Development Criterion
- To expand network steadily from Bangkok metropolitan area to outside areas

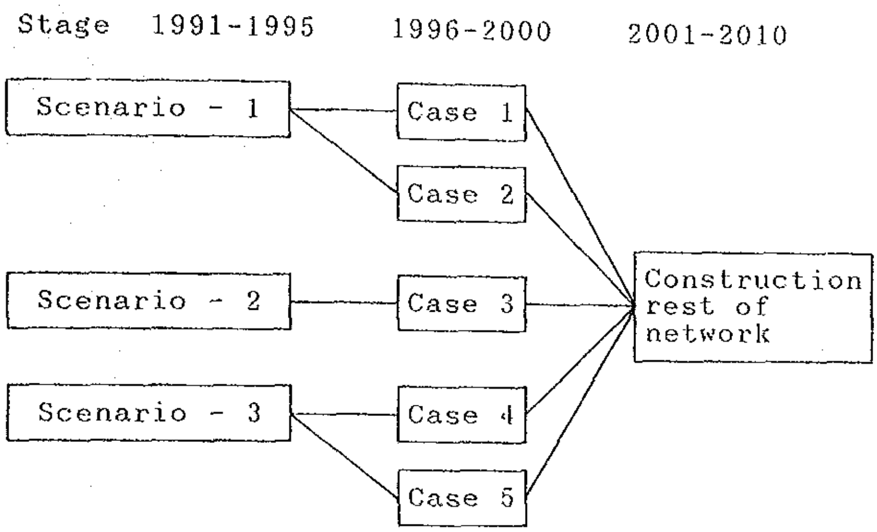
Scenario — 3: Arterial Routes Promotion Criterion
- To place high priority on arterial backbone routes to connect Bangkok with regions or between regions.

For the expanding variations in the second 5 years (1996-2000), two cases are prepared for each of Scenario-1 and -3, and 5 (five) alternative staging cases are established as below and illustrated in Figure 10.1.

5) Benefit Estimation by Alternative

The benefits of the proposed motorway network by alternative staging case are presented in Tables 10.38 to 10.44, as savings in VOC and in time costs.

ALTERNATIVE STAGING PLANS



The VOC itself will increase from 1995 to 2010 in all alternatives. But the benefits of VOC savings in 2010 will be lower than those of 1995 and 2000 because the diversion of vehicles to the higher speed motorways will be accelerated by the completion of the motorway network. Although vehicle-km on low speed links in the national highway network will be reduced in this situation, diversion of vehicles to links of higher speed, hence, higher unit cost of VOC (at speeds of 110 KPH or 120 KPH) will offset the former effects.

The benefits of induced traffic are estimated to be about 3 to 8% of the benefits of normal traffic.

Some adjustments are added to the estimated benefits shown in Table 10.43. In the established alternative staging cases, each stage is intended to be completed at the end of 1995 (first stage), 2000 (second stage) and 2010 (third stage) respectively. Corresponding benefits to each staging network, therefore, will be realized in 1996, 2001 and 2011. These one year adjustments are added by applying average growth rates of traffic and the results are presented in Table 10.44.

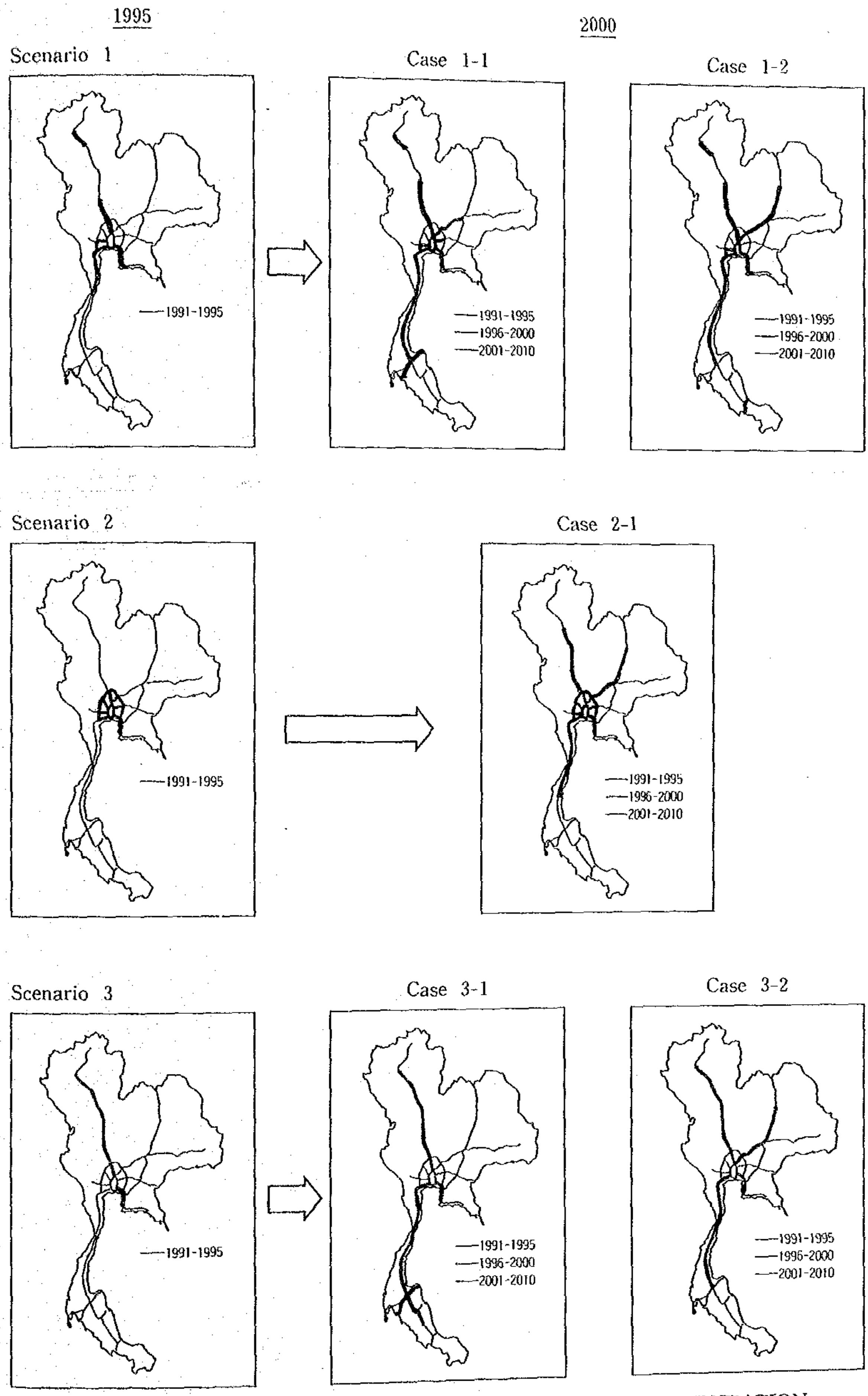


Figure 10.1 ALTERNATIVE STAGING CASES FOR IMPLEMENTATION

Table 10.38 VEHICLE OPERATING COST BY ALTERNATIVE CASE

(Million Baht/Year)

Year	Without	Case 1	Case 2	Case 3	Case 4	Case 5
1995	302,770	289,317	289,317	282,861	290,720	290,720
2000	379,764	334,023	346,886	329,280	346,457	341,303
2010	619,268	608,987	608,987	608,987	608,987	608,987

Table 10.39 VOC SAVING BENEFIT (Million Baht/Year)

Year	Case 1	Case 2	Case 3	Case 4	Case 5
1995	13,453	13,453	19,909	12,050	12,050
2000	45,741	32,878	50,484	33,307	38,461
2010	10,281	10,281	10,281	10,281	10,281

Table 10.40 TIME COST BY ALTERNATIVE CASE (Million Baht/Year)

Year	Without	Case 1	Case 2	Case 3	Case 4	Case 5
1995	62,468	58,232	58,232	57,372	56,455	56,455
2000	86,652	67,427	73,457	66,129	70,974	68,801
2010	152,628	113,352	113,352	113,352	113,352	113,352

Table 10.41 TIME COST SAVING BENEFIT (Million Baht/Year)

Year	Case 1	Case 2	Case 3	Case 4	Case 5
1995	4,236	4,236	5,096	6,013	6,013
2000	19,225	13,195	20,523	15,678	17,851
2010	39,276	39,276	39,276	39,276	39,276

Table 10.42 BENEFIT OF INDUCED TRAFFIC (Million Baht/Year)

Year	Case 1	Case 2	Case 3	Case 4	Case 5
1995	460	460	858	414	414
2000	4,601	2,431	5,634	2,203	3,162
2010	2,665	2,665	2,665	2,665	2,665

Table 10.43 TOTAL BENEFIT (Million Baht/Year)

Year	Type of Benefit	Case 1	Case 2	Case 3	Case 4	Case 5
1995	VOC	13,453	13,453	19,909	12,050	12,050
	Time	4,236	4,236	5,096	6,013	6,013
	Induced	460	460	858	414	414
	Total	18,149	18,149	25,863	18,477	18,477
2000	VOC	45,741	32,878	50,484	33,307	38,461
	Time	19,225	13,195	20,523	15,678	17,851
	Induced	4,601	2,431	5,634	2,203	3,162
	Total	69,567	48,504	76,641	51,188	59,474
2010	VOC	10,281	10,281	10,281	10,281	10,281
	Time	39,276	39,276	39,276	39,276	39,276
	Induced	2,665	2,665	2,665	2,665	2,665
	Total	52,222	52,222	52,222	52,222	52,222

Table 10.44 ADJUSTED TOTAL BENEFIT (Million Baht/Year)

Year	Type of Benefit	Case 1	Case 2	Case 3	Case 4	Case 5
1996	VOC	14,691	14,691	21,741	13,159	13,159
	Time	4,626	4,626	5,565	6,566	6,566
	Induced	502	502	937	452	452
	Total	19,819	19,819	28,242	20,177	20,177
2001	VOC	48,440	34,818	53,463	35,272	40,730
	Time	20,359	13,974	21,734	16,603	18,904
	Induced	4,872	2,574	5,966	2,333	3,349
	Total	73,671	51,366	81,163	54,208	62,983
2011	VOC	10,888	10,888	10,888	10,888	10,888
	Time	41,593	41,593	41,593	41,593	41,593
	Induced	2,822	2,822	2,822	2,822	2,822
	Total	55,303	55,303	55,303	55,303	55,303

10.3.3 Regional Development Effects (Indirect Benefits)

In Thailand, the main objective of building the motorway network is to promote economic activities both for the country as a whole, and for each area to raise the living standards of the local society.

From this viewpoint, it is very important to consider the indirect effects resulted by the completed motorway network. Broadly divided, these effects can be grouped into 7 categories as follows:

— Betterment of Nationwide Development,
— Promotion of Manufacturing Industries,
— Promotion of Tourism,
— Promotion of Agriculture and Fisheries,
— Promotion of Commercial Activities,
— Improvement in Living Conditions, and
— Others.

Since many of these effects cannot be estimated in monetary terms, they are evaluated by means of comparing the transportation conditions in the existing highway network with those of the future motorway network.

1) Betterment of Nationwide Development

The motorway network will shorten distances between different areas in the country in terms of travel time. When the motorway network, which connects five regional urban centers together, is completed, the travel time between Bangkok and Chiang Mai, Khon Kaen, Nakhon Rachasima, Chon Buri and Song Khla will be shortened by about 40% as shown in Figure 10.2. Through such improved transportation conditions as less travel time, the motorway network will bring large opportunities for encouraging development of industry, agriculture, tourism and other socio-economic activities in the core cities as well as in their surrounding areas. These new conditions will provide jobs through industrial development, reduce disparities in income, and produce a more balanced distribution of population.

2) Promotion of Manufacturing Industries

Factories and facilities of relevant businesses will be constructed along the motorways, especially in the vicinity of interchanges, since the motorways will offer speedy and on-

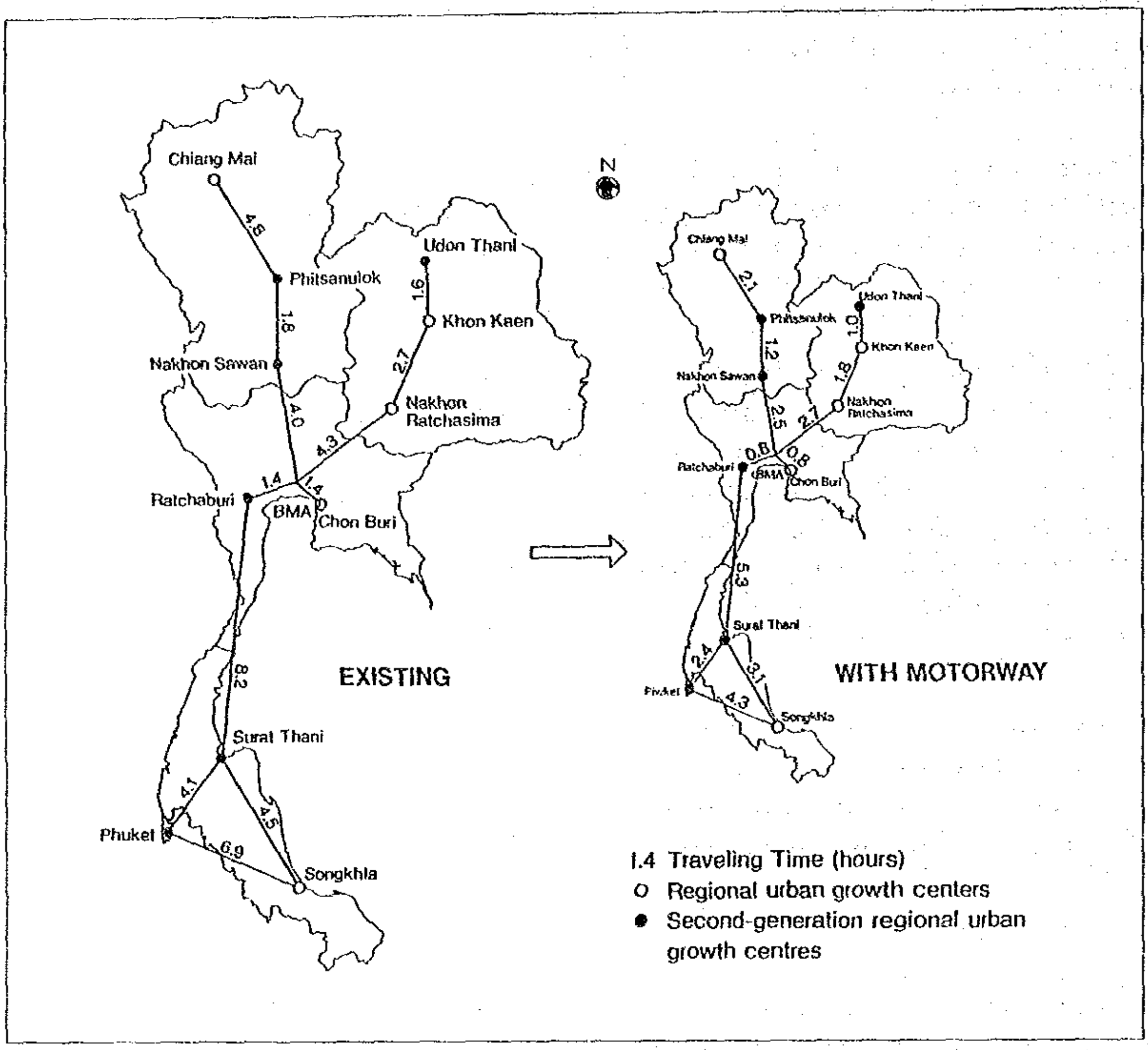


Figure 10.2 BETTERMENT OF NATION WIDE DEVELOPMENT

schedule transport of raw materials and products. Figure 10.3 shows the location of industrial estates in the Central Region by travel time from Bangkok for both the existing highway network and the proposed motorway network. Accordingly, almost all of them are located within a 2-hour time distance from Bangkok. So when the proposed motorway network is put into service, the area which will be available for the development of industrial estates will become 4 times as large as the present one.

3) Promotion of Tourism

According to the statistics published by the Tourism Authority of Thailand, the number of international tourists has shown a

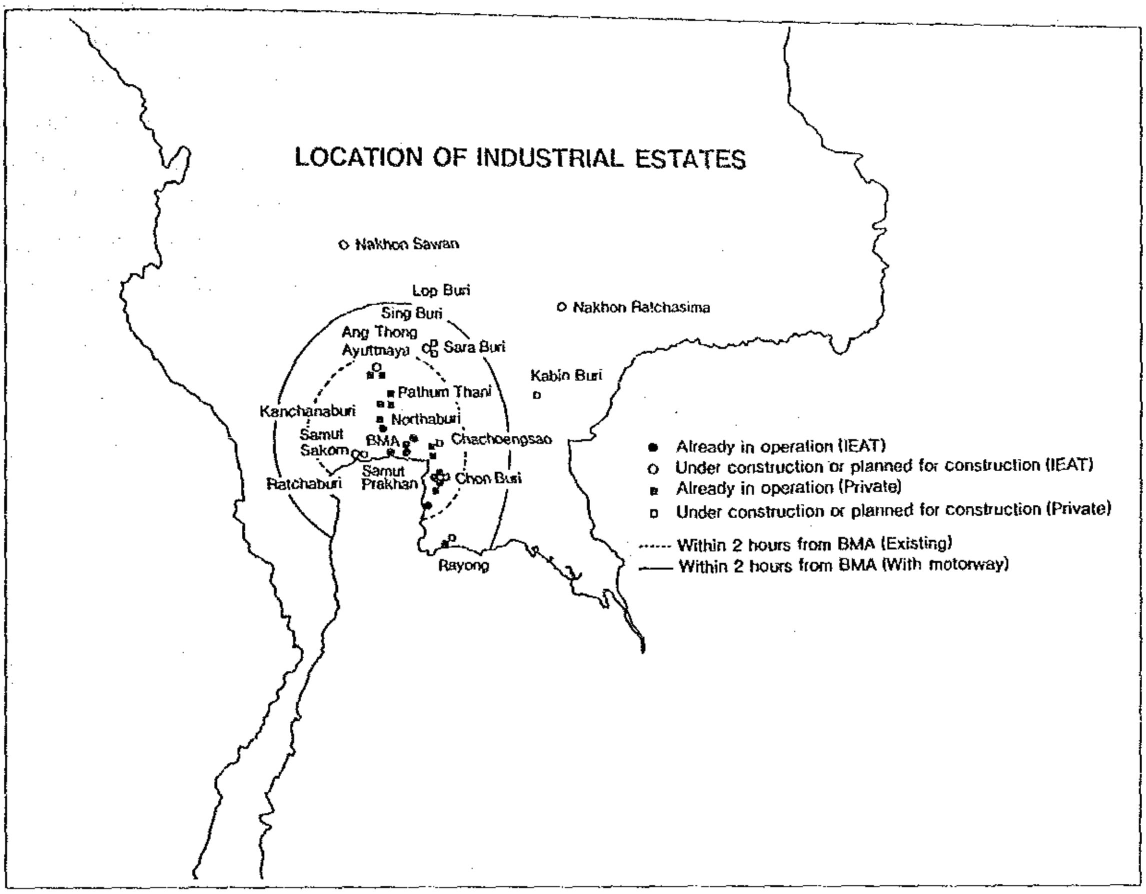


Figure 10.3 LOCATION OF INDUSTRIAL ESTATES

remarkable growth, standing at 4.2 million in 1988, nearly doubling that of five years before. International tourism has been contributing greatly to increasing foreign exchange revenues for Thailand.

Even though a large number of foreigners is visiting Thailand, there are still many attractive sites and areas which are not visited by them because of their remote locations. Figure 10.4 shows that if the tourists travel on the proposed motorway network, they will be able to enjoy more sites within a day. For instance, those who travel in Chiang Mai and its suburbs within one day, will be able to visit Chiang Mai, Chiang Rai, Sukhothai, and Phitsanulok.

Further, the southern part of Hua-hin and eastern part of Rayong will no doubt prove to be suitable areas for marine resorts. Consequently, these movements will stimulate tourism industry in the areas concerned.

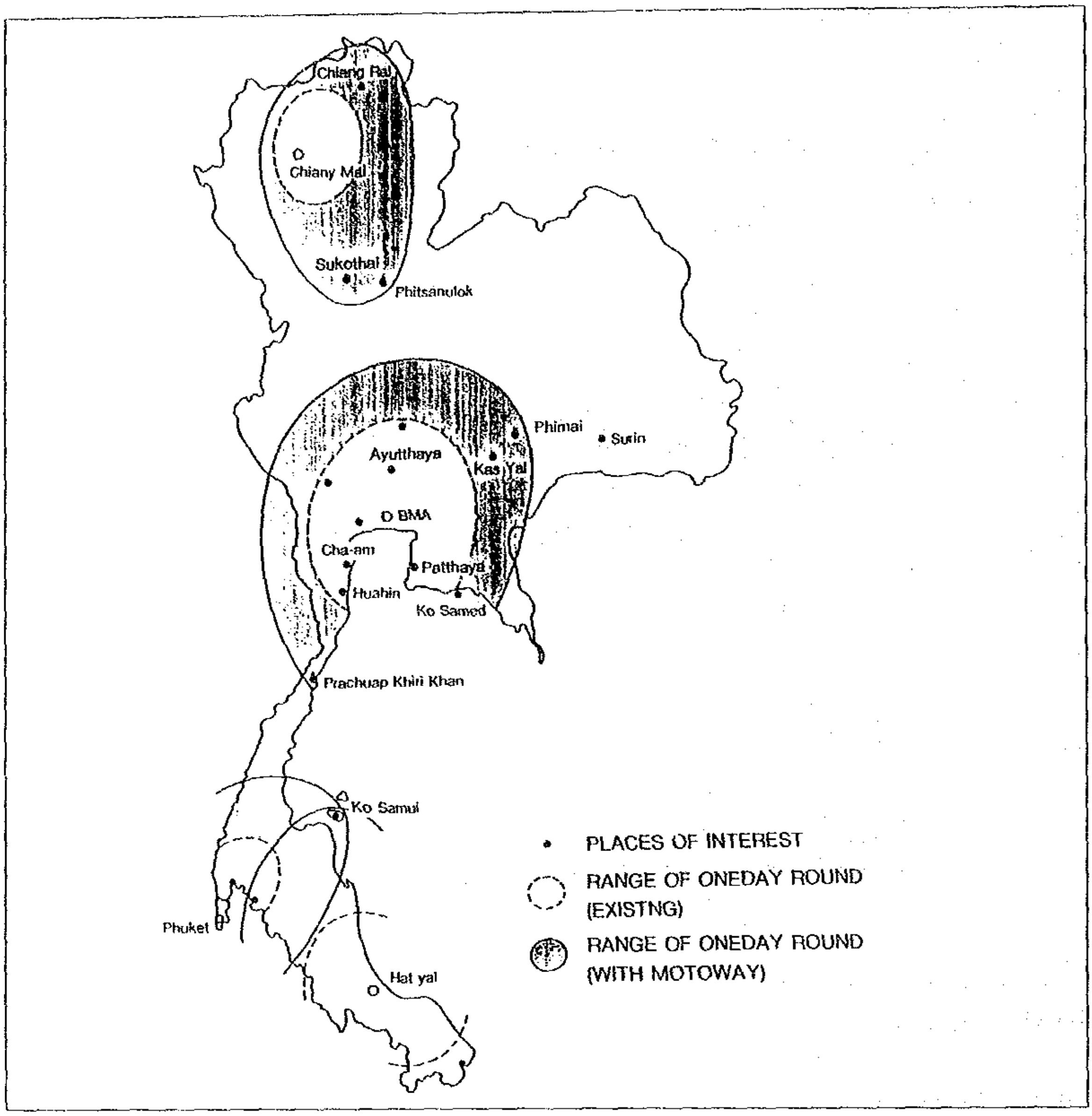


Figure 10.4 RANGES OF ONE DAY ROUND TRIP FROM MAJOR CITIES

4) Promotion of Agriculture and Fisheries

The motorway network will encourage new factories to be constructed in the roadside areas, and at the same time, will stimulate production activities in such existing industries as agriculture and fisheries.

Freshness is a vital factor for such products as vegetables, fruits, flowers and fishery products. Currently, asparagus is being produced in Nakhon Ratchasima, orchids in the suburbs of Bangkok and strawberries in the area surrounding Chiang Mai, while shrimps are being cultivated in the suburbs of Bangkok and in Songkhula as shown in Figure 10.5. The development of the motorway network, which will cut down the time required for delivering the products to the markets as well as food processing plants, will make it possible to grow and cultivate such products in other districts. This will no doubt contribute substantially to promoting Thailand's national policy of building the nation into a newly agro-industrializing country.

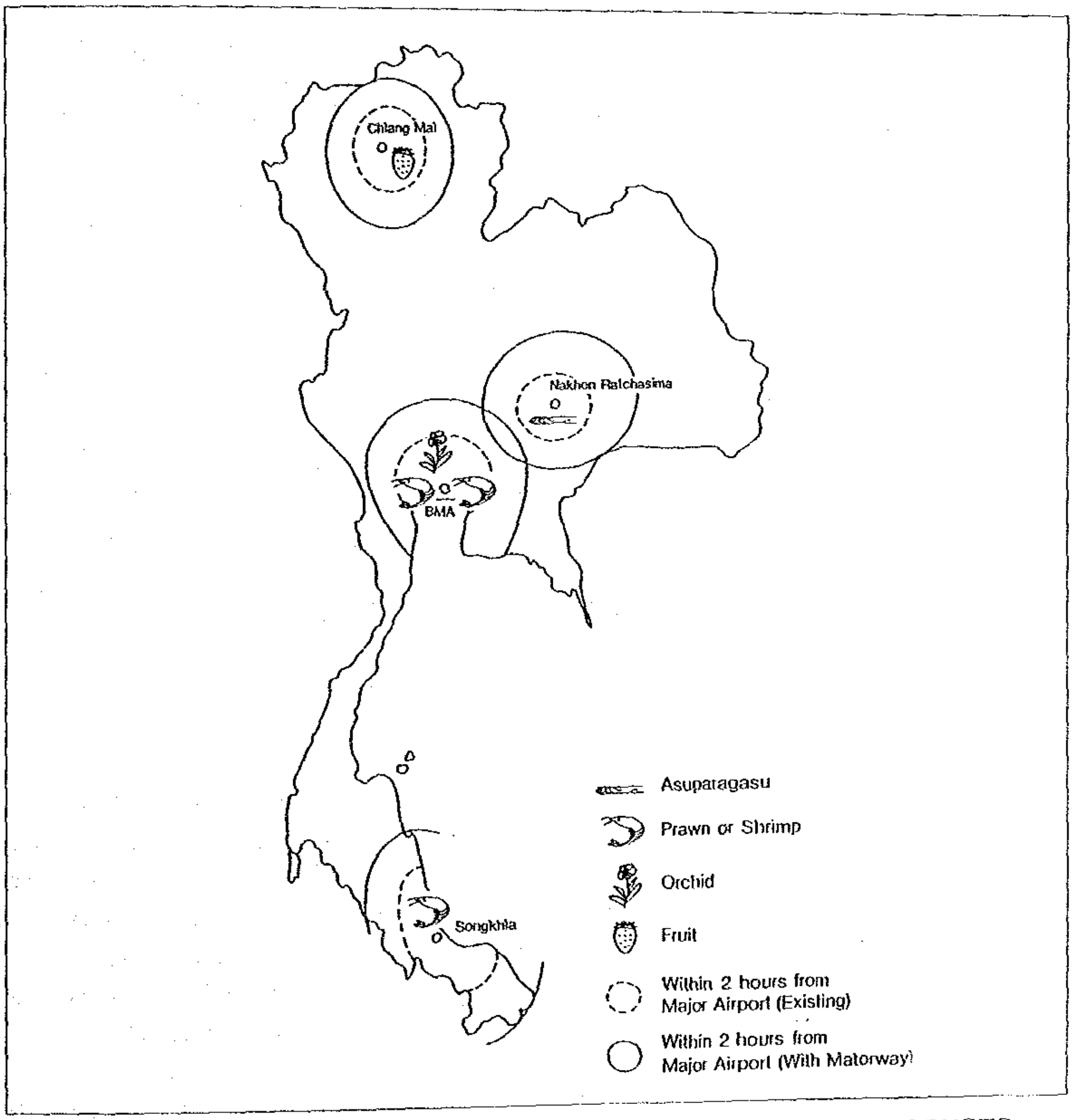


Figure 10.5 LOCATION OF AGRICULTURAL AND FISHERY PRODUCTS

5) Promotion of Commercial Activities

With the reduction in the travel time, commercial activities will be stimulated in both cases of the domestic exchange and foreign exchange with neighboring countries. Figure 10.6 shows that the travel time will be reduced to two thirds after completion of the proposed motorways.

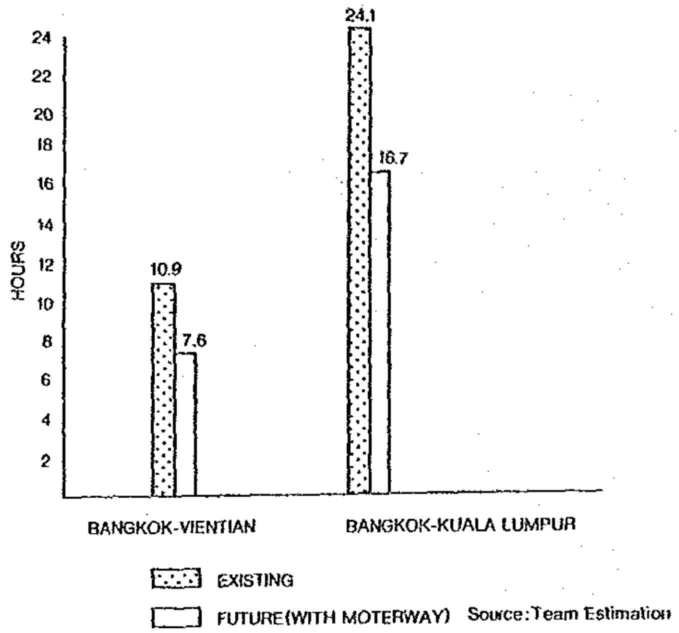
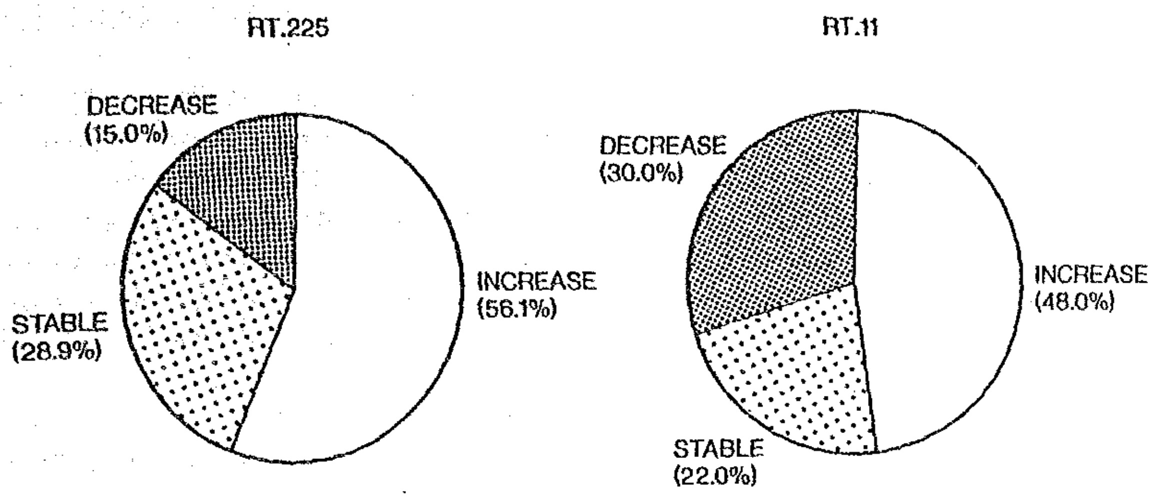


Figure 10.6 COMPARISON OF INTERNATIONAL TRAVELING TIME

6) Improvement in Living Conditions

Opening the motorway network will promote development of industries, thereby increasing both shipment and employment as well as income not only for individuals but also for the Government. The improvement in transportation conditions with the motorway network may also help remarkably people in local areas in utilizing and gaining access to such social service facilities as hospitals, schools, government offices, among others.

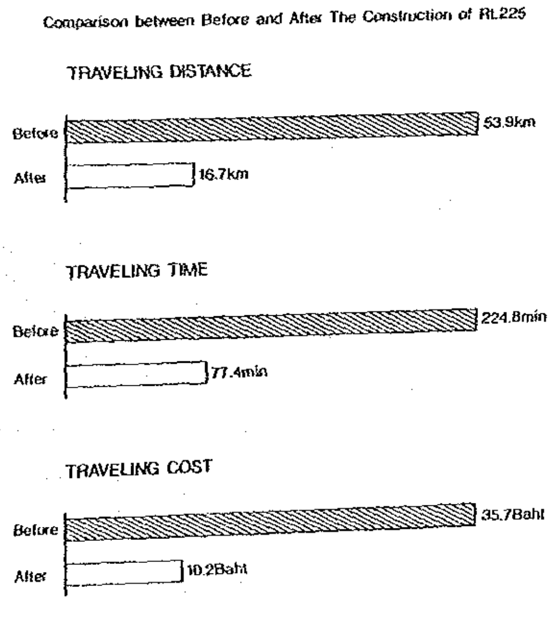
Figure 10.7 shows the difference in the average income of the people, who live along Route 225 and Route 11 of the national highway, before and after constructing the highways. According to this figure, about half of the people have increased their average income level.



Source:Post Evaluation Study for Rt. 225 and
DOH's Annual Report, 32

Figure 10.7 CHANGE OF INCOME AFTER CONSTRUCTION

Figure 10.8 also shows the difference in transportation conditions for the people along Route 225, between before and after construction. According to this figure, all transportation conditions such as travel distance, travel time, and travel cost have dropped to about one third of what they had been before construction.



Source:Post Evaluation Study for Rt.225

Figure 10.8 DIFFERENCE IN TRIPS TO VISIT HOSPITAL

7) Others

The construction of the motorway network inevitably affects social, economic and cultural exchange on both inter-regional and international levels. The construction of the network will also ensure safe, comfortable and speedy driving to people utilizing the network. Consequently, it will stimulate service competition among the different modes of transportation and lead to improve railway and air services as well.

Figure 10.9 shows a comparison of the travel time between Bangkok and other major cities by vehicle (before and after construction) and by railway and air. It can be seen that the travel time from Bangkok to Hat Yai, Chaing Mai and Khon Kaen by vehicle has been shortened by 6, 4, and 2 hours respectively. In the case of Khon Kaen, in particular, it can be seen that vehicles can almost compete with airplanes in terms of travel time.

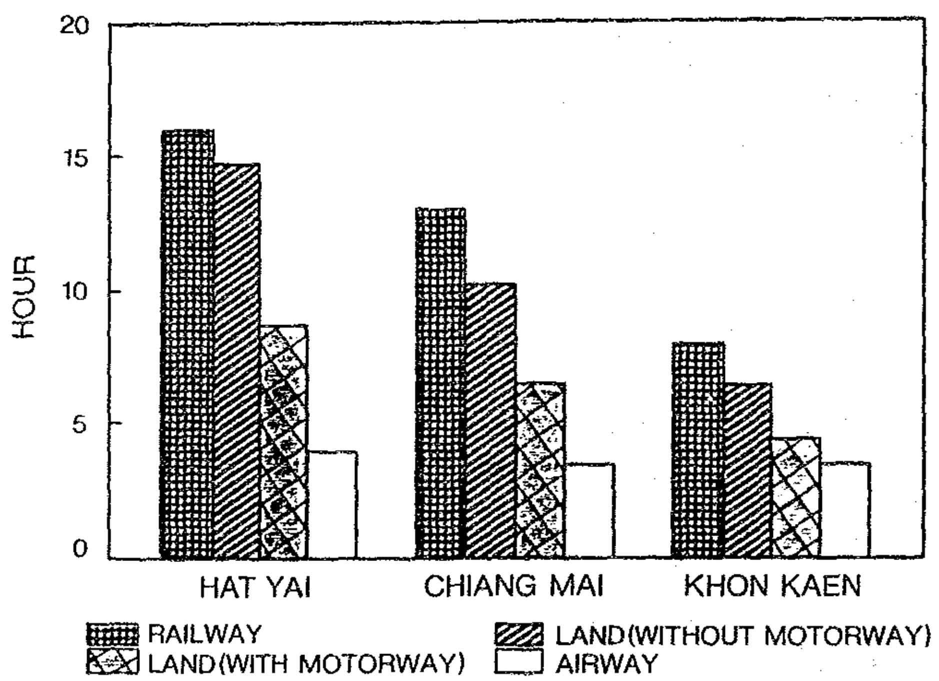


Figure 10.9 TRAVELING TIME FROM BMA BY MODE

10.4 ECONOMIC ANALYSIS

Economical justification of the proposed motorway network is investigated by comparing the economic costs with the economic benefits of each alternative staging case.

10.4.1 Economic Costs

1) Construction Cost

Economic construction cost is calculated by applying the average conversion factor (0.90) to the financial construction costs (except for land acquisition cost). The average conversion factor is decided by reviewing the recent study of "Road Development Study in the Central Region, JICA, 1989".

The construction cost of each alternative staging case is summarized in Table 10.45.

Table 10.45 ECONOMIC CONSTRUCTION COST (million Baht in 1990 price)

Case	1991-1995	1996-2000	2001-2010
Case 1	80,830.3	84,979.4	157,009.0
Case 2	80,830.3	83,941.8	158,046.0
Case 3	113,704.1	59,440.5	149,674.1
Case 4	54,488.5	61,329.1	207,001.0
Case 5	54,488.5	64,759.0	203,571.2

2) Maintenance and Operation Cost

Economic maintenance and operation cost is estimated as 363,000 Baht/km/year and 454,000 Baht/km/year respectively, also by applying the same conversion factor.

10.4.2 Conditions for Economic Analysis

Conditions of economic benefit-cost analysis are described below:

a. Construction costs of each stage are equally allocated to the years contained in the corresponding planning period.

b. Benefits are assumed to be generated from the next year after completion.

c. Benefit streams between the years 1996-2001 and 2001-2011 are estimated by means of interpolation.

d. Annual benefits after the year 2011 are assumed to be the same benefits as in the year 2011.

e. No residual value is assumed for all alternatives.

10.4.3 Results of Economic Analysis

Results of the economic analysis are shown in Table 10.46 and cost benefit cash flows are shown in Appendix 10.7. Of these alternative plans, the internal rate of return ranges from 23% to 35% and all alternatives are considered to be economically feasible.

Although Case 5 (Arterial Routes Promotion Criterion) shows the highest Economic Internal Return Rate (EIRR), contribution to the Net Present Value (NPV) of Case 5 is almost the same as Case 1 (Traffic Volume Criterion). It seems that the results of the analysis indicate no substantial difference in alternative plans.

Table 10.46 SUMMARY OF ECONOMIC EVALUATION

Index	Case 1	Case 2	Case 3	Case 4	Case 5
EIRR(%)	27.78	23.09	27.75	33.40	35.44
*NPV (million Baht)	133,094	91,098	154,544	117,356	133,160
*B/C	2.01	1.69	2.07	2.05	2.19

Note: * Discount Rate = 12%

It is important for the establishment of implementation plans, to take into account the other factors as well, not only the economic returns but also such a main factor as the contribution to the regional development, which is not quantified as benefits.

Considering progress of ongoing development projects (Eastern Sea Board, for example) and the promotion of regional development in local areas in the next 5 years, Staging Case 1 (Traffic Volume Criterion) is recommendable as the most efficient implementation plan.

10.4.4 Economic Sensitivity Analysis

Sensitivity analysis for the Staging Case 1 is carried out to provide probabilistic judgment on the investment. Evaluation indicators are calculated on various projections and summarized in Table 10.47.

Table 10.47 RESULTS OF ECONOMIC SENSITIVITY ANALYSIS

Projections	Evaluation Indicators		
	EIRR (%)	NPV* (million Baht)	B/C*
Base Case	27.78	133,094	2.01
(1) Benefits down by 10%	25.00	106,633	1.81
(2) Benefits down by 20%	22.07	80,172	1.61
(3) Costs up by 10%	25.26	119,942	1.83
(4) Costs up by 20%	23.06	106,790	1.68
(5) Costs up by 10% and Benefits down by 10%	22.61	93,481	1.65
(6) Costs up by 20% and Benefits down by 20%	17.88	53,868	1.34

Note; * Discount Rate = 12%

The sensitivity analysis above shows that even if the project costs go up by 20% and benefits go down by 20% simultaneously, an EIRR of more than 17% is still maintained.

CHAPTER ELEVEN

FINANCIAL EVALUATION

CHAPTER 11

FINANCIAL EVALUATION

11.1 FINANCIAL COST

11.1.1 Financial Construction Cost

Financial construction costs in 1990 price are presented in the previous chapter, and summarized in Table 11.1.

Table 11.1 FINANCIAL CONSTRUCTION COST

	(million Baht in 1990 price)		
Stage	1991—1995	1996—2000	2001—2010
Case 1	88,807.8	94,030.8	172,992.2
Case 2	88,807.8	92,946.0	174,077.0
Case 3	125,180.5	65,655.8	164,994.5
Case 4	59,926.6	67,682.9	228,221.3
Case 5	59,926.6	71,536.1	224,368.1

Costs under inflation are also studied by using an increase rate of 5% per annum (source: "Quarterly Bulletin", Bank of Thailand, June 1989) and the results are presented in the following section.

11.1.2 Financial Maintenance and Operation Costs

Financial unit costs of maintenance and operation are as estimated in the previous chapter and shown below in 1990 price.

Maintenance Cost: 400,000 Baht/km/year
Operation Cost : 500,000 Baht/km/year

Effects of inflation on these costs are also taken into account assuming the same escalation rate of 5% per annum.

11.2 TOLL RATE

The proposed motorways are planned to be operated as toll roads and basic toll rates are set at 1.0 Baht/km for light vehicles, and 2.0 Baht/km for medium and heavy vehicles. Determination of a reasonable toll structure is an essential problem. This section, therefore, is devoted to discuss whether that toll rates are reasonable or not.

11.2.1 Criteria for Toll Rate Determination

There are 2 (two) criteria for the determination of toll rates as described below:

1) Possibility of repayment of loaned investment costs within a given payback period.
   - A toll rate that will enable the total project costs to be covered by the total revenue.

2) Equity and rationality
   - A reasonable toll rate compared with fares of other transport modes with reasonable difference between light and heavy vehicles.

Toll rates which satisfy the first criterion are usually determined through a calculation of repayment programme under some conditions. The second criterion is examined here by comparing the toll rate of passenger cars (1.0 Baht/km) with railway fare.

11.2.2 Generalized Costs of Toll Motorways and Railways

A simple comparison of the toll rate with railway fare is not enough to judge the situation because another important factor for modal choice, i.e., service level (travel time) is omitted. The generalized cost including travel time is expressed as follows:

$$S(i) = F(i) + T(i) * V$$

where, S(i) : generalized cost by mode (i)
F(i) : fare or fee by mode (i)
T(i) : travel time by mode (i)
V : value of travel time

The fares and travel time, for example, between Bangkok and Lop Buri (with a distance of about 130 km which is the average trip length on toll motorways) are summarized in Table 11.2.

Table 11.2 TIME AND COST OF RAILWAY AND MOTORWAY

Mode	Time (hours)			Cost (Baht/person)		
	Access & Egress	Line Haul	Total	Access & Egress	Line Haul	Total
Railway	1.5	*3.0	4.5	20.0	*28.0	48.0
Tollway	1.3	1.4	2.7	20.3	**93.9	114.2

Source: * Time Table of the State Railway of Thailand, August 12, 1990.

Notes : ** 93.9 Baht = (toll fee 130 Baht + petrol 133 Baht) / 2.8 passengers per vehicle

- Average speed on toll motorways is assumed to be at 90 km.
- Access & egress distance to interchanges are assumed to be 25 km with speed of 40km/hr respectively.
- Access & egress to/from railway stations by bus include waiting time.

The generalized cost by each mode is presented below:

$$S\,(rail) = 48.0 + 4.5 * V$$
$$S\,(toll) = 114.2 + 2.7 * V$$

The time value that splits into the two modes is calculated from the above equations as follows:

$$V = 36.8 \text{ Baht/hour/person}$$

The above value of V is not higher than the average time value of a passenger on business trip estimated in the previous chapter (39.8 Baht/hour). An average passenger on business trip by a passenger car will, therefore, get some benefits if he/she uses the toll motorways instead of railways under the condition of 1.0 Baht/km toll rate as shown below:

Value of saving time	=	39.8 Baht/hr. * (4.5 − 2.7)hrs
	=	71.6 Baht
Additional cost	=	114.2 Baht − 48.0 Baht
	=	66.2 Baht
Net benefit	=	71.6 Baht − 66.2 Baht
	=	5.4 Baht

The result above indicates that the toll rate of 1.0 Baht/km for passenger car is reasonable compared to the railway fare.

11.3 FINANCIAL ANALYSIS

Financial analysis is conducted for the same alternatives assessed in the economic analysis comparing the toll revenues against the costs of investment and maintenance and toll operation cost.

11.3.1 Toll Rate and Revenues

The toll rate for two vehicle groups is determined as follows:

1.0 Baht/km − − − PC, LB, PP and LT

2.0 Baht/km − − − MB, HB, MT and HT

Toll revenues by each alternative plan are calculated by applying the above toll rates, and the results are summarized in Table 11.3.

Table 11.3 TOLL REVENUES (million Baht/year)

Year	1996	2001	2011
Case 1	3,465	15,453	54,625
Case 2	3,465	11,475	54,625
Case 3	4,700	16,121	54,625
Case 4	3,908	11,397	54,625
Case 5	3,908	12,892	54,625

Periodical revision of toll rates to cover the effect of inflation is also assumed. An average annual increase rate of 3% is applied (General Price Index in Transportation Sector: "Quarterly Bulletin", Bank of Thailand, June 1989) and the toll rates are assumed to increase every 5 (five) years by using the above rate.

11.3.2 Financial Returns

The financial cash flows by staging case are shown in Appendix 11.1. The Financial Internal Rate of Return (FIRR) is estimated to be around 13% to 14% and no substantial differences are observed among the staging cases, as shown in Table 11.4.

Table 11.4 FINANCIAL EVALUATION

Case	Case 1	Case 2	Case 3	Case 4	Case 5
FIRR(%)	12.88	13.09	12.54	14.16	14.03

If the average interest rate of investment costs can be reduced under the rate of 12% by various combinations of available funds, these alternatives will be financially viable.

11.3.3 Repayment Schedule

Cash flow estimation for repayment is conducted for Staging Case 1 in order to find the year in which the flow begins to yield a surplus and the year in which the total accumulated revenues exceed the accumulated expenditures.

Assumptions of the estimation are described below:

— Funds of investment in financial terms:

In this estimation, the following 2 (two) programmes are prepared as combinations of fund resources:

Programme — 1:

Source (A): Loan from an international financial institution

40% of total annual investment
Interest Rate: 3.0% per annum
Repayment Period: 30 years including 10—year grace period

Source (B): Loan from a syndicate of major local Banks

60% of annual investment
Interest Rate: 15.0% per annum
Repayment Period: 20 years including 5—year grace period

Programme — 2:

Source (A): Loan from an international financial institution

40% of total annual investment
Interest Rate: 9.0% per annum
Repayment Period: 20 years including 5—year grace period

Source (B): The same conditions as the source (B) of Programme—1

- Price escalation: 5% per annum for construction cost, and maintenance and operation costs

- Revenues: Toll rate revision at every 5 years with an increase rate of 3% per annum

- Short term loan: To cover the shortage in cash with an interest rate of 15% per annum

The estimated cash flows of Programme—1 and —2 are shown in Appendices 11.2 and 11.3.

Through the estimation, the followings are pointed out:

- The first year in which the annual revenue exceeds the total annual expenditures will be 2007 in Programme—1 and 2009 in

Programme—2 (15 years and 17 years after the first opening respectively).

- The year of the break even point in which the accumulated revenues exceed the accumulated expenditures will be 2014 in Programme—1 and 2016 in Programme—2 (22 and 24 years after the first opening respectively).

- The maximum accumulated deficit will reach an amount of 134,598 million Baht by Programme—1 and 234,565 million Baht by Programme—2 in 2007.

- The total amounts of interest to be paid until the end of repayment period are as follows:

Table 11.5 AMOUNTS OF INTEREST CHANGES (million Baht)

Programme	Source	Total Interest
Programme-1	(A)	107,442.2
	(B)	547,620.6
	(Short-term Loan)	19,593.1
Programme-2	(A)	219,048.2
	(B)	547,620.6
	(Short-term Loan)	33,520.5

The total interest charges for source (A) by Programme—2 will be two times of that by Programme—1.

The above estimations are conducted assuming that the project will be implemented as public works, although no subsidies from the Government are taken into account in the calculation.

If the toll motorways are operated by the private sector, other cost components such as depreciation allowance, taxes and deposit/reserve should be taken into account as well in the above estimations.

11.3.4 Financial Sensitivity Analysis

Sensitivity analysis on financial evaluation for the proposed motorways are also carried out from various aspects. In these analysis, Staging Case 1 is selected and tested to estimate the effects of changes in the assumptions prepared for the original evaluation. The assumptions and factors to be checked are as follows:

- Changes in the original costs and revenues.
- Changes in the price escalation rate for annual investment costs, and maintenance and operation costs.
- Changes in the rates of interest.
- Changes in toll rates applied in the base case.

1) Changes in Costs and Toll Revenues

a. Effects on Financial Return

Sensitivity tests are executed to estimate the effects of changes in the original financial costs and toll revenues on financial return (FIRR). Results of tests are summarized in Table 11.6.

Table 11.6 EFFECTS ON FINANCIAL RETURN (FIRR:%)

Costs / Revenues	Base Case	+10%	+20%
Base Case	12.88	12.06	11.33
-10%	11.98	11.18	10.47
-20%	10.99	10.22	9.52

The results indicate that if the estimated original costs and revenues of the base case go up by 20% and down by 20% respectively, FIRR goes down from 12.88% to 9.52%.

b. Effects on Repayment Schedule

Effects of changes in costs and revenues on the repayment schedule of Case 1 are examined for the following two situations:

- Costs go up by 10% and revenues go down by 10%
- Costs go up by 20% and revenues go down by 20%

The years in which the cash flows begin to yield an annual surplus and accumulated net surplus (break even points) are estimated and summarized in Table 11.7.

Table 11.7 CHANGES OF THE YEAR OF BREAK EVEN POINT (STAGING CASE 1)

Loan Condition	Programme-1		Programme-2	
	Annual Surplus	Accumulated Surplus	Annual Surplus	Accumulated Surplus
Base Case	2007	2014	2009	2016
Costs +10% and Revenue -10%	2010	2017	2012	2019
Costs +20% and Revenue -20%	2013	2020	2014	2021

The results indicate that 10% of positive/negative changes in costs and revenues will cause 3 years of delay of the break even point. In the case of 20% variation, the year will be delayed for 5—6 years compared to the base case.

The years in which the maximum accumulated deficits are observed and the amounts of these deficits are summarized in Table 11.8.

Table 11.8 CHANGES IN MAXIMUM DEFICITS (million Baht)

Loan Condition	Programme-1		Programme-2	
	Maximum Deficit	Year	Maximum Deficit	Year
Base Case	134,598	2007	234,565	2007
Costs +10% and Revenue -10%	218,587	2007	389,817	2012
Costs +20% and Revenue -20%	388,681	2012	568,500	2012

The maximum accumulated deficits by Programme—1 will be changed 1.6 times of the base case with +10%/—10% of cost/revenue variation and 2.9 times of the base case with +20%/—20% variation. In the case of Programme—2, the deficit will turn into more severe situation.

2) Changes in Price Escalation Rate

a. Effects on Financial Return

In the base case, project costs including construction cost and maintenance and operation costs are assumed to increase by an average annual price escalation rate of 5%. Effects of changes in price escalation rate are examined here for the cases of 7% p.a. and 10% p.a. The results are shown in Table 11.9.

Table 11.9 EFFECTS OF CHANGES IN PRICE ESCALATION RATE ON FIRR

Price Escalation Rate	FIRR (%)
5 % p.a. (Base Case)	12.88
7 % p.a.	11.18
10 % p.a.	7.62

As shown in the table, the case of 2% increase in price escalation rate (from 5% to 7%) results in the same financial return as in the case of 10% cost up and 10% of revenue down which is shown in Table 11.6. The case of 10% escalation rate will result in a severe financial situation unless some counterpolicies are adopted.

If the same value of FIRR of the original case (12.88%) is to be maintained even under the 10% of escalation rate, toll rates have to be revised every 5 years with an increasing rate of 5.4% per annum instead of 3.0% in the original case.

b. Effects on Repayment Schedule

The effects of changes in price escalation rates on repayment schedule are also examined at the rates of 7% and 10% per annum respectively. The break even point will be delayed for 3 — 5 years comparing with the base case if the escalation rate is changed to 7% p.a. In case of 10% escalation rate, the break even point will be delayed for 8 — 10 years as presented in Table 11.10.

Table 11.10 EFFECTS OF CHANGES IN PRICE ESCALATION RATE ON BREAK EVEN POINT

Loan Condition	Programme-1		Programme-2	
Escalation Rate	Annual Surplus	Accumulated Surplus	Annual Surplus	Accumulated Surplus
Base Case (5% p.a.)	2007	2014	2009	2016
7% p.a.	2012	2017	2013	2019
10% p.a.	2017	2024	2017	2026

Table 11.11 shows the effects of changes in price escalation rate on the amounts of the maximum accumulated deficit.

The effects of price escalation on the total investment cost are shown in Table 11.12. Total investment cost will increase to 1.7 times of that in 1990 price in case of 5% escalation rate (Base Case), 2.2 times in case of 7% p.a. and 3.1 times in case of 10% p.a.

Table 11.11 EFFECTS OF CHANGES IN PRICE ESCALATION RATE ON MAXIMUM ACCUMULATED DEFICIT (million Baht)

Loan Condition	Programme-1		Programme-2	
	Maximum Deficit	Year	Maximum Surplus	Year
Base Case (5% p.a.)	134,598	2007	234,565	2007
7% p.a.	247,443	2013	434,651	2012
10% p.a.	706,432	2016	1,007,504	2016

Table 11.12 EFFECTS OF CHANGES IN PRICE ESCALATION RATE ON INVESTMENT COST (million Baht)

Escalation Rate	(A) 1990 price	(B) Base Case (5% p.a.)	(C) 7% p.a.	(D) 10% p.a.
Investment Cost	355,831	614,457	774,683	1,109,297
		(B/A)=1.7	(C/A)=2.2	(D/A)=3.1

3) Changes in Rates of Interest

Effects of changes in rates of interest on the repayment schedule are examined for the following cases:

Programme-1:

Source (A): 3.0% p.a. for the base case is revised to 6.0% p.a.

Source (B) and Short Loan: 15.0% p.a. is revised to 18.0% p.a.

Programme-2:

Source (A): 9.0% p.a. is revised to 12.0% p.a.

Source (B) and Short Loan: 15.0% p.a. is revised to 18.0% p.a.

Effects of the above changes on the break even point, amounts of maximum deficits and total interest amounts are summarized in Tables 11.13 to 11.15.

Table 11.13 EFFECTS OF CHANGES IN RATES OF INTEREST ON BREAK EVEN POINT

Interest Rate		Annual Surplus	Accumulated Surplus
Programme-1			
Source (A)	(B)		
3.0% p.a.	15.0% p.a.	2007	2014
6.0% p.a.	18.0% p.a.	2009	2016
Programme-2			
Source (A)	(B)		
9.0% p.a.	15.0% p.a.	2009	2016
12.0% p.a.	18.0% p.a.	2012	2018

An additional interest rate of 3% will result in 2—3 years of delay of break even point, as presented in Table 11.13.

Table 11.14 EFFECTS OF CHANGES IN RATES OF INTEREST ON MAXIMUM ACCUMULATED DEFICIT (million Baht)

Interest Rate		Maximum Deficit	Year
Programme-1			
Source (A)	(B)		
3.0% p.a.	15.0% p.a.	134,598	2007
6.0% p.a.	18.0% p.a.	217,427	2008
Programme-2			
Source (A)	(B)		
9.0% p.a.	15.0% p.a.	234,565	2007
12.0% p.a.	18.0% p.a.	339,987	2012

An additional interest rate of 3% to the base case will result in about 60% and 45% increase of the maximum accumulated deficits for Programme—1 and Programme—2 respectively, as indicated in Table 11.14.

Table 11.15 EFFECTS OF CHANGES IN RATES OF INTEREST ON AMOUNTS OF INTEREST CHARGES (million Baht)

Programme	Interest Rate	Source (A)	Source (B)	Short Loan
1	(A) 3.0% p.a. (B) 15.0% p.a.	107,442	547,621	19,593
	(A) 6.0% p.a. (B) 18.0% p.a.	214,885	657,145	39,137
2	(A) 9.0% p.a. (B) 15.0% p.a.	219,048	547,621	33,521
	(A) 12.0% p.a. (B) 18.0% p.a.	292,064	657,145	61,403

Table 11.15 indicates that the total of interest charges, including short loan interests, will increase from 674,700 million Baht in the Programme—1 to 911,100 million Baht by an

additional 3% of interest rate. In Programme-2, total interest burden will increase from 800,000 to 1,010,600 million Baht.

4) Changes in Toll Rates

The basic toll rates are set at 1.0 Baht/km for light vehicles and 2.0 Baht/km for medium and heavy vehicles in the Base Case. Sensitivity to toll rates is tested in terms of toll elasticity of traffic demands and financial conditions.

The following 2 (two) alternative toll structures are prepared for sensitivity tests:

Toll Structure-A:
0.25 Baht/km -- Light Vehicles
0.50 Baht/km -- Medium and Heavy Vehicles

Toll Structure-B: (Base Case)

Toll Structure-C:
1.5 Baht/km -- Light Vehicles
3.0 Baht/km -- Medium and Heavy Vehicles

a. Toll Elasticity of Traffic Demands

Traffic demands in vehicle-km, by applying the three toll structures are estimated through the traffic assignment and results are summarized in Table 11.16.

Table 11.16 TOLL STRUCTURE AND TRAFFIC DEMANDS ON TOLL MOTORWAYS (ALL VEHICLES)

Year	(1000 Vehicle-km/day) Toll Structure A	B Base Case	C	Toll Elasticity A <--B-->	C
1995	10,874	6,989	5,418	0.74	0.45
2000	35,306	29,929	21,759	0.24	0.55
2010	122,732	107,498	78,509	0.19	0.54

Note: Toll Elasticity of Traffic Demand = [Changes in Traffic Demand (%)]/[Changes in Toll Rates (%)]

The toll elasticity of traffic demand is less than unity. When the elasticity is less than 1 at a given toll rate and demand, adecrease (increase) in toll rate is accompanied by a less proportional increase (decrease) in traffic demand and total toll revenue decreases (increases). This is the case of inelastic demand. The total toll revenues by each toll structure are as shown in Table 11.17.

Table 11.17 TOLL STRUCTURE AND TOLL REVENUE (million Baht/year)

Year	Toll Revenue		
	Toll Structure		
	A	B (Base Case)	C
1996	1,439	3,465	3,935
2001	4,761	15,453	16,732
2011	16,411	54,625	59,182

b. Financial Returns

The Financial Rate of Return (FIRR) for each toll structure is calculated as presented in Table 11.18.

Table 11.18 FIRR BY TOLL STRUCTURE

	Toll Structure		
	A	B (Base Case)	C
FIRR (%)	3.42	12.88	13.61

FIRR will sharply decrease to 3.42% in the case of toll structure—A.

c. Repayment Schedule

The years in which cash flows begin to yield an annual surplus and accumulated net surplus (break even point year) are also estimated for each toll structure as shown in Table 11.19.

Table 11.19 CHANGES IN BREAK EVEN POINT YEAR BY TOLL STRUCTURE

Loan Condition	Programme-1		Programme-2	
Toll Structure	Annual Surplus	Accumulated Surplus	Annual Surplus	Accumulated Surplus
Base Case	2007	2014	2009	2016
A	2019	2031	2019	2033
C	2007	2012	2008	2015

The break even point years of accumulated surplus by toll structure—A will be delayed for 17 years compared to the base case.

The years in which the maximum accumulated deficits are observed and deficit amounts for each toll structure are summarized in Table 11.20.

Table 11.20 CHANGES IN MAXIMUM DEFICITS BY TOLL STRUCTURE

(million Baht)

Loan Condition	Programme-1		Programme-2	
Toll Structure	Maximum Deficit	Year	Maximum Deficit	Year
Base Case	134,598	2007	234,565	2007
A	729,631	2017	896,354	2017
C	108,542	2004	206,486	2007

The toll structure—A will result in about 5.4 times of the maximum deficit of the base case in Programme—1 and 3.8 times in Programme—2.

11.4 TREATMENT OF TOLL ROAD SYSTEM AFTER COMPLETION OF REPAYMENT

11.4.1 Repayment Principle and Toll Road System

The financial evaluation of motorways presented in the above sections is based on a principle that the construction costs are provided with loaned funds to be repaid by toll revenues. The repayment principle is defined that the construction costs of motorways should be covered by appropriate toll charges within an appropriate payback period and the motorways should be made toll-free after completion of the repayment.

The repayment principle is, therefore, strongly connected with the toll road system in a sense. Although the repayment principle is one of necessary conditions to introduce the toll road system (i.e. charging tolls for the repayment), it is not a sufficient condition because there are other reasons, explained in the following section, to continue charging tolls on motorway users even after the completion of repayment.

11.4.2 Toll Road System after Completion of Repayment

Regarding the toll road system after completion of repayment for the whole proposed network, it is necessary to discuss the following points:

(1) Size of Motorway Network after the Year 2010

The proposed motorways in the target year 2010 compose a network of about 4,300 km in length. Although the plan itself is a big project, development of regional and national economy will proceed further beyond the target year and sooner or later the size of the proposed network will become insufficient compared to economic level.

Under these circumstances, additional motorway links, hence additional funds for the construction, will become necessary to expand the network for supporting socio-economic development. Therefore, toll road system should be maintained even after the completion of repayment of the 4,300 km network, and toll revenues/surplus after that can be used for additional land acquisition/construction. The policy above will enable toll rates in future to be kept at lower level than the rates based on another external funds.

(2) Inter—Generation Equity

The proposed network is planned to be constructed by the end of

2010 and repayment of its investment costs will finish in 2030 (Programme—1) or 2025 (Programme—2), only 15—20 years after the construction. Roads have, in general, a long life and generations after the completion of repayment will surely use the motorways as well. If the motorways are to be made toll-free after the completion of repayment, it will result in transfer of income from generations who share the burdens to generations to which users or beneficiaries after repayment belong. it is recommendable, therefore, to maintain the toll road system even after the completion of repayment to avoid the above inequity.

(3) Maintenance Cost of Motorways

Motorways have different characteristics and different functions from ordinary highways: access control, better alignment, good surface condition, etc. It is these characteristics that provide users of motorways with high quality of services and enable motorways to handle a lot of through traffic.

Annual maintenance and repair works for motorways are necessary to maintain their functions regardless the repayment is finished or not. The costs of maintenance, repair and operation of motorways, therefore, should be covered by collecting toll charges even after the completion of repayment.

11.5 VALUE CAPTURE

11.5.1 Concept and Definition of Value Capture

The development effects of motorways can be clearly observed especially in areas adjacent to interchanges. The new construction of motorways and new interchanges will increase accessibility to/from adjacent land and will increase attraction of such land as new location sites for industrial and commercial activities. These effects are gradually reflected in increase of land values/land prices. The development gains above are windfalls to owners or users of real estates/buildings located in the land and main part of these gains will belong to them unless any capture policies are adopted.

The Value Capture Policy is a system that absorbs the development gains from beneficiaries of external economies and returns the captured amounts to investment costs of motorways in order to fill the deficits or to reduce the burdens of users' toll charges.

11.5.2 Methods for Value Capture Policy

Some methods for the value capture policy have been presented theoretically and some others have been implemented actually in various countries. The followings are examples of value capture policy:

1) Imposing the Capital Gain Tax on Increased Land Values

The most theoretically suitable method for the value capture method is to impose the tax to a capital gain caused by construction of interchange. But it is difficult to apply this method in actual situation because an increase of land price is usually the result of variation in many factors and it is difficult to estimate separately the effect of interchanges on land price increase. In addition, capital gains will not be realized unless the land is sold.

2) Prior Acquisition of Excess Land together with Right-of-Way

The land acquisition for road construction is usually limited to the right-of-way. However, if the excess land adjacent to interchange can be purchased by an execution body together with the right-of-way, the development gains will be able to capture by selling or lease the excess land for higher prices after opening the interchange.

A problem of this method is who pays for the excess land before starting construction. The execution body may not be able to acquire any excess land while they continue the construction of motorways because of shortage of funds. This method, however, is recommendable if funds for excess land are available.

3) Joint Development

Application of the joint development concept could stimulate programs of other local governments by which the local cities can meet some of their needs for better housing, parks, playgrounds, open space, and other improvements, and for private business and commercial redevelopment by combining them with planned motorways and interchange construction.

The advantages which can flow from joint development are that several of these facilities and improvements necessary for the regional developments can be provided in less total space and at lower total cost than would occur with the separate development of each of the components. Joint development will make the land acquisition for interchanges more easier, and the construction cost may be reduced by sharing out the cost among all the participants of the development (private sector, local government and execution agency).

CHAPTER TWELVE

IMPLEMENTATION SCHEDULE

CHAPTER 12

IMPLEMENTATION SCHEDULE

12.1 IMPLEMENTATION SCHEDULE

As described in Chapter 10, the economic evaluation is carried out for 5 alternative staging plans. The results of the evaluation, however, indicate no substantial difference among the alternative plans, and the alternative Scenario Staging—1, Case 1 is selected as the most appropriate plan by placing stress on the relationship of the on—going national development project, e.g., Eastern Seaboard Development Project.

The implementation schedule is established so as to complete the whole motorway network of about 4,300 km during 20 years from 1991 to 2010. The average length of the section to be completed a year reaches 215 km. During the first five years, however, the yearly average is planned to be only 173 km, and then increases to 216 km during the following five years. Constructing nearly half of the network will put Thailand in a well experienced position to complete the network with a higher average of 240 km during the last ten years. The implementation schedule is shown in Table 12.1. The outline of this schedule is as follows:

a. Stage 1 (5 years from 1991 to 1995)

Seven sections of about 860 km in total are included in this stage. They are determined by selecting an important section related to Eastern Seaboard Development Project (TM—3) and other congested sections of motorways toward Northern and Southern Regions (TM-1, TM-4, TM-31, TM-32 and TM-36), and a section near Chiang Mai for promoting regional development.

b. Stage 2 (5 years from 1996 to 2000)

Seven sections of about 1,070 km in total are included. Until the end of the stage 2, the following sections are expected to be completed.

Table 12.1 IMPLEMENTATION SCHEDULE

ROUT/SECTION			LENGTH(km)	1991-1995	1996-2000	2001-2010
TM-1 (755.6km)						
BANG PA-IN J.C.	-	NAKON SAWAN	175.5	━━		
NAKON SAWAN	-	PHITSANULOK	141.5		━━	
PHITSANULOK	-	LAMPANG	182.0			━━
LAMPANG	-	CHAIANG MAI	90.7	━━		
CHAIANG MAI	-	CHIANG RAI	165.9			━━
TM-2 (535.5km)						
BANG PA-IN J.C.	-	N. NAKHON RATCHASIMA	206.0		━━	
N. NAKHON RATCHASIMA	-	NONG KAI	329.5			━━
TM-21 (301.1km)						
NAKHON RATCHASIMA	-	UBON RATCHATANI	301.1			━━
TM-3 (291.9km)						
PHRA KHANONG	-	RAYONG	197.3	━━		
RAYONG	-	CHANTABURI	94.6			━━
TM-31 (167.7km)						
BANG PA-IN JC.	-	PHRA KHAONG	53.1		━━	
PHRA KHAONG	-	PHASI CHAROEN	51.2	━━		
PHASI CHAROEN	-	BANG PA-IN JC.	63.4		━━	
TM-32 (100.0km)						
BANG YAI	-	BANG PHONG J.C.	53.0	━━		
BANG PHONG J.C.	-	KANCHANABURI	47.0			━━
TM-33 (62.0km)						
BANG BUA THONG	-	SUPHAN BURI	62.0			━━
TM-34 (211.7km)						
THANYABURI	-	NAKHON NAYOK	59.0		━━	
NAKHON NAYOK	-	ARRANYAPRATHET	152.7			━━
TM-35 (239.1km)						
CHON BURI	-	NAKHON RATCHASIMA	239.1			━━
TM-36 (365.8km)						
WAT PHLENG	-	BANG PANG	41.3	━━		
BANG PANG	-	BANG PAKONG	324.5			━━
TM-4 (951.4km)						
PHASI CHAROEN J.C.	-	PRACHUAP KHIRI KHAN	257.7	━━		
PRACHUAP KHIRI KHAN	-	BAN NA SAN	365.3		━━	
BAN NA SAN	-	MALAYSIA BORDER	328.4			━━
TM-41 (190.7km)						
KRABI	-	KHANOM	190.7		━━	
TM-42 (136.0km)						
PHRA SAENG	-	PHUKET	136.0			━━
TM-43 (36.9km)						
RON PHIBUN	-	NAKHON SI THAMARAT	36.9			━━
TOTAL LENGTH (km)			4,345.4	866.7	1,079.0	2,399.7

- TM-1: the section between Bangkok and Phitsanulok
- TM-2: the section between Bangkok and Nakhon Ratchasima
- TM-4 & TM-41: the section between Bangkok and Krabi-Khanom
- TM-31: the whole section of the Outer Bangkok Ring Motorway

A motorway network of about 1,900 km in total completed through the stages 1 and 2 will raise a certain impact of the new erea of motorways in Thailand.

c. Stage 3 (10 years from 2001 to 2010)

Remaining 13 sections of about 2,400 km are included in this stage, so the whole sections of the proposed motorway network will be completed.

The sections classified by each stage are shown in Figure 12.1.

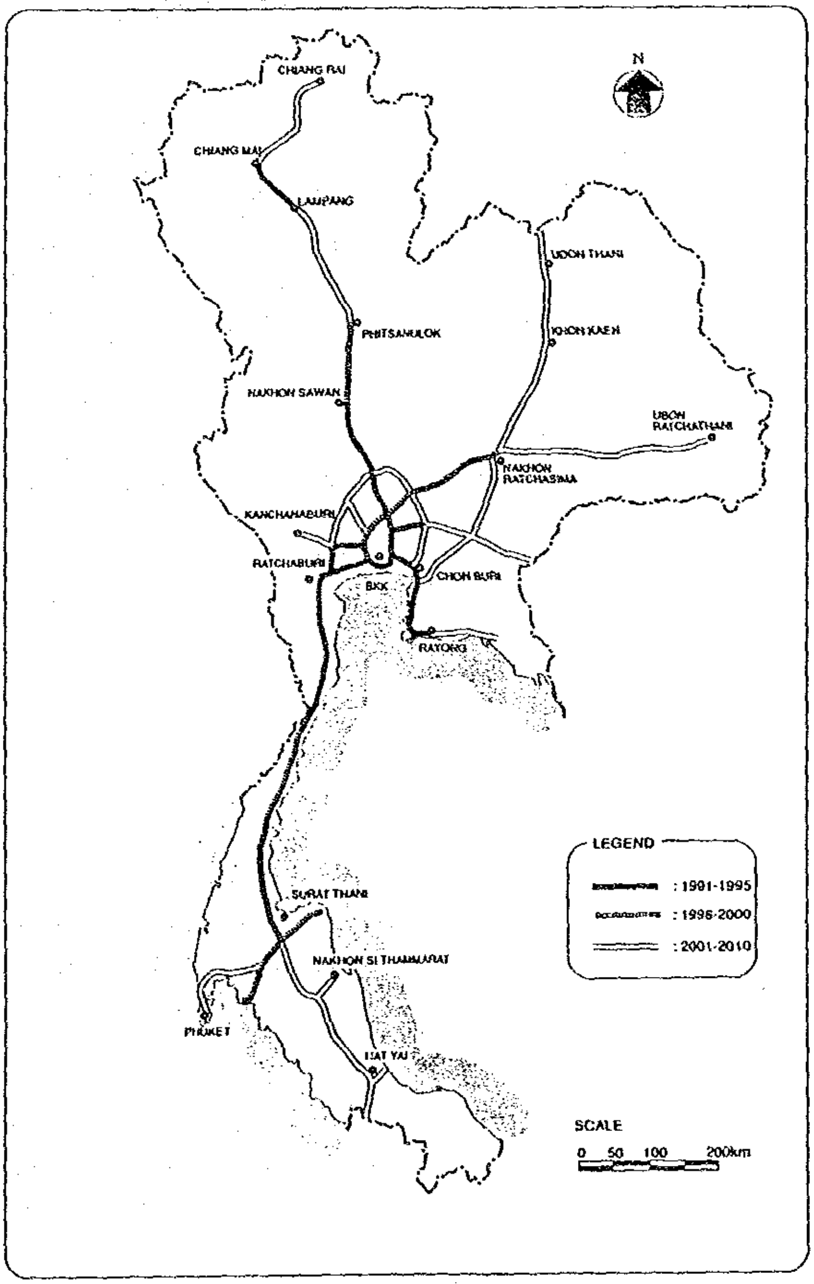


Figure 12.1 STAGING PLAN OF SCENARIO-1, CASE 1

12.2 INVESTMENT PROGRAM

As described in Chapter 10, the implementation of the motorway network requires a huge amount of investment. A total investment for the whole motorway network of about 4,300 km is estimated to be 355,831 million Baht.

Table 12.2 shows the investment allocated to each implementation stage with amounts of the price escalation.

Table 12.2 INVESTMENT AMOUNT BY STAGE (million Baht)

	1991-1995	1996-2000	2001-2010	Total
Construction Cost	88,808	94,031	172,992	355,831
Price Escalation	14,243	45,226	199,157	258,626
Total	103,051	139,257	372,149	614,457
Composition (%)	(17.1)	(23.1)	(59.9)	(100)

From this table, amounts of the annual investment are calculated as follows:

Stage 1 : 20,610 million Baht/year
Stage 2 : 27,851 million Baht/year
Stage 3 : 37,215 million Baht/year

12.3 FUTURE STUDY

This study is the master plan study to formulate the nationwide motorway network. In order to realize the implementation of every route, a feasibility study at more details and with accurate level is required.

The study proposes to urgently carry out the feasibility study for the routes included in stage 1 of the implementation schedule.

These routes, with their length and origins and destinations are shown in Table 12.3.

Table 12.3 PROPOSED ROUTES FOR FEASIBILITY STUDY

Route No.	Origin	Destination	Length (km)
TM−1	Bang Pa−In J.C. (Ayutthaya)	− Nakhon Sawan	175.5
TM−1	Lampang	− Chiang Mai	90.7
TM−3	Pattaya J.C. (Chon Buri)	− Rayong	52.0
TM−4	Phasi Charoen J.C. (BMA)	− Prachuap Khiri Khan	257.7
TM−31	Phra Khanog (Samut Prakarn)	− Phasi Charoen J.C. (BMA)	51.2
TM−32	Bang Yai (BMA)	− Ban Pong J.C. (Nakhon Pathom)	53.0
TM−36	Wat Phleng (Ratchaburi)	− Ban Pong (Nakhon Phathom)	41.3
TOTAL			721.4

The route between Bangkok and Pattaya is excluded from the routes in the table since the feasibility study for this route has already been done in the "Road Development Study in the Central Region", JICA, 1989.

JICA