1/ It was presumed that the average bus trip length in the future will be shortened to about 15 km in accordance with increase of use of bus services in town areas.

2/ It was also presumed that the average bus occupancy will increase to around 25 persons per vehicle because of increase of city buses.

3/ It was presumed that bus routes will increase to around 500 km in the future in order to cover development project areas.

4/ Total demand of person trips is the total value of person trips to make use of public buses and passenger cars.

5-2 The Strategic Alternative Networks

5-2-1 Alternative 0

The road projects which are being implemented or which have been decided to be implemented by the Government and are scheduled to be completed during the period of the next five-year program are set as Alternative 0 to be used as the base case for other alternatives.

The road network of the base case is as shown in Fig. 5-1. The bus network and the level of bus services are the same as those of the current situations. (See Fig. 5-5, Table 5-3)

It is anticipated, based on the results of forecast of the traffic volume, that traffic congestion will occur at many places in the future due to increase of traffic volume, regardless of investment on roads by the government. (See Fig. 6-8)

Selection of the projects to be the objects of additional investment for solving occurrence of traffic congestion, which is faborable from the standpoint of national economy, is therefore a problem.

Accordingly, the following directions are examined for setup of alternatives.

① To make additional investment to roads in order to solve the problem of traffic congestion, in the case where cars are the principal means for transport at they are up to the present time.

② To develop bus services and to make investment on road to a certain extent. In this case, the level of bus services and the road construction level will vary by the assumed bus split ratio.

5-2-2 Alternative 1

This is a program to cope with the traffic demand increase in the future by the development of a road system.

Basically, the number of lanes will be increased for the roads where congestion is anticipated (congestion rate 1.0 and up) in the result of the future traffic assignment in alternative 0.

For increasing the number of lanes in concrete, priority will be given to expansion of trunk roads, and in the case where utilization of lands along the roads has advanced and expansion of road widths is hard, trunk roads located in parallel with subject roads will be expanded.

The results are shown in Fig. 5-2 and Table 5-4. The bus network and the level of bus services are same as those of the current situation. (See Fig. 5-5, Table 5-3)

5-2-3 Alternative 2

Alternative 2 is the plan to develop the bus network to the maximum based on the road network of Alternative 0.

Buses will be operated at a total average operating frequency (total average operation interval about 12 minutes) which is four times of the current frequency because it is anticipated that the bus split ratio is assumed as 25% at maximum.

It is expected as a result that the car traffic volume of Alternative 2 will be reduced by about 25%, but congestion on roads of congestion rate 1.3 or higher in the result of the future traffic assignment in Alternative 0 cannot be solved. It is therefore necessary to increase the number of lanes of these roads. The areas in which 4-lane roads are additionally required in the road network of Alternative 2 are surroundings of Rimba and Lambak housing project areas and town center of B.S.B. (See Fig. 5-3, Table 5-4)

The present bus network is mainly constituted by inter-city bus lines, and its future population coverage ratio 1/ is as minor as 52%. Consequently, it causes occurrence of mass intra-city car mobilization.

1/ Future population coverage ratio =

$$\frac{\text{Future population distributed in a 500 m zone along bus route}}{\text{Total future population}} \times 100$$

In order to improve this situation, the following bus network is proposed as a desirable plan.

① To newly open bus routes to almost all development scheduled areas.

② To newly open bus routes as much as possible to area having no bus routes at the present time, as long as roads which permit passage of buses are available.

③ To newly open a circular bus route around B.S.B. in addition to radial bus routes.

④ To introduce high speed bus routes which make connection among major cities by making use of expressways for long distance trips.

⑤ To provide bus terminals at transfer points between main bus routes and at terminals where main bus routes are concentrated, in order to improve convenience and confort of passengers.

⑥ To provide bus stops equipped with bus bays, shelters, chairs, time tables, etc. in order to improve time-schedule observance and passengers' convenience and confort.

The future population coverage ratio of bus routes established in such a manner will be improved to 75%. In addition, the daily average operating interval of the highest frequency is improved to 5 minutes, and the daily average operating interval of the lowest frequency even is largely improved to 20 minutes. (See Fig. 5-6, Table 5-3)

5-2-4 Alternative 3

Alternative 3 assumes a bus split ratio of around 15 - 20%.

Accordingly, the bus service level will be improved to a total average operating frequency (total average operation interval 17 minutes) which is about three times of the value at the present time.

It is anticipated as a result that the car traffic volume of Alternative 3 will decrease by about 15 - 20%, but congestion on roads of congestion rate 1.2 and up in the result of the future traffic assignment of Alternative 0 will not be solved. It is therefore necessary to increase the number of lanes of these roads. The numbers of lanes of roads of Alternative 3 are as shown in Fig. 5-3, Table 5-4 and the road network is same as that of Alternative 2.

The bus network of Alternative 3 is almost same as that of Alternative 2, and the total average operating frequency will be about three times as much as that of the present time. Accordingly, the daily average operation interval will be improved to 10 minutes for the bus routes of the highest frequency, and it will be improved to 30 minutes for bus routes of the lowest frequency. (See Fig. 5-6, Table 5-3)

5-2-5 Alternative 4

Alternative 4 assumes the bus split ratio of around 10%.

Accordingly, the bus service level will be improved to a total average operating frequency (total average operation interval 27 minutes) which is about twice of the value at the present.

It is anticipated that the car traffic volume of Alternative 4 will be reduced by about 10%. Accordingly, it is necessary to increase the number of lanes of roads of congestion rate 1.1 and up in the result of the future traffic assignment of Alternative 0.

The result is as shown in Fig. 5-4 and Table 5-4. That is, the number of lanes is increased for some sections in Jalan Gadong in addition to the road network of Alternatives 2 and 3.

The bus network of Alternative 4 is same as that of Alternatives 3. As the total average operating frequency will be improved to about twice of the present, the average operation intervals of individual bus routes are improved as shown in Table 5-3.

Table 5-2 General Comparison by Alternative Plans

		Alternative				
		0	1	2	3	4
Road	. Existing Roads	o	o	o	o	o
	. Roads under Construction	o	o	o	o	o
	. Proposed Roads by the Team		o	o	o	o
Bus and Bus Route	. Existing Bus and Bus Route	o	o			
	. Improved Bus and Bus Route			o	o	o
	. Increasing Bus Frequency			o	o	o
	. Improvement of New Bus Terminals and Bus Stops			o	o	o
Parking Facilities	. Existing Facilities	o	o	o	o	o
	. New Parking Facilities to Meet with Parking Demand		o	o	o	o

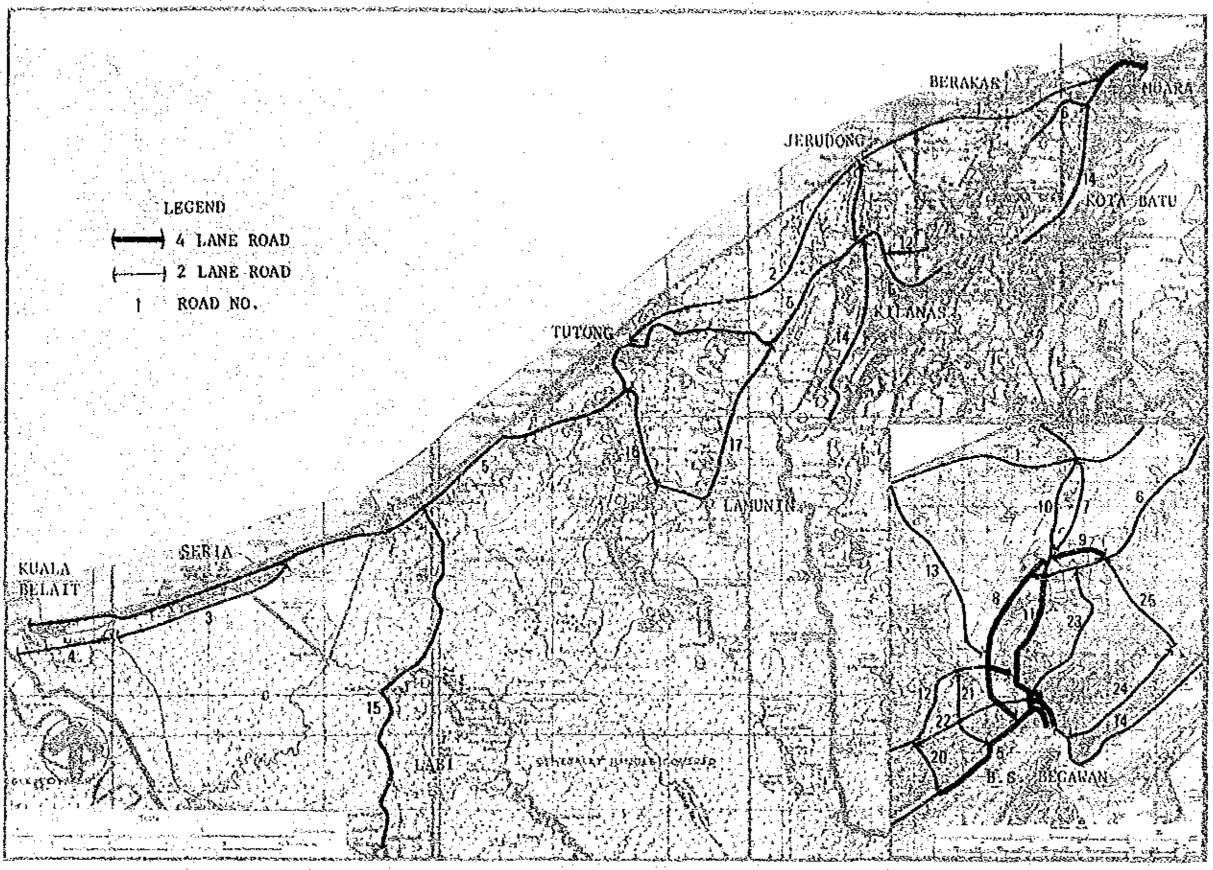


Fig. 5-1 Road Network (Alternative 0)

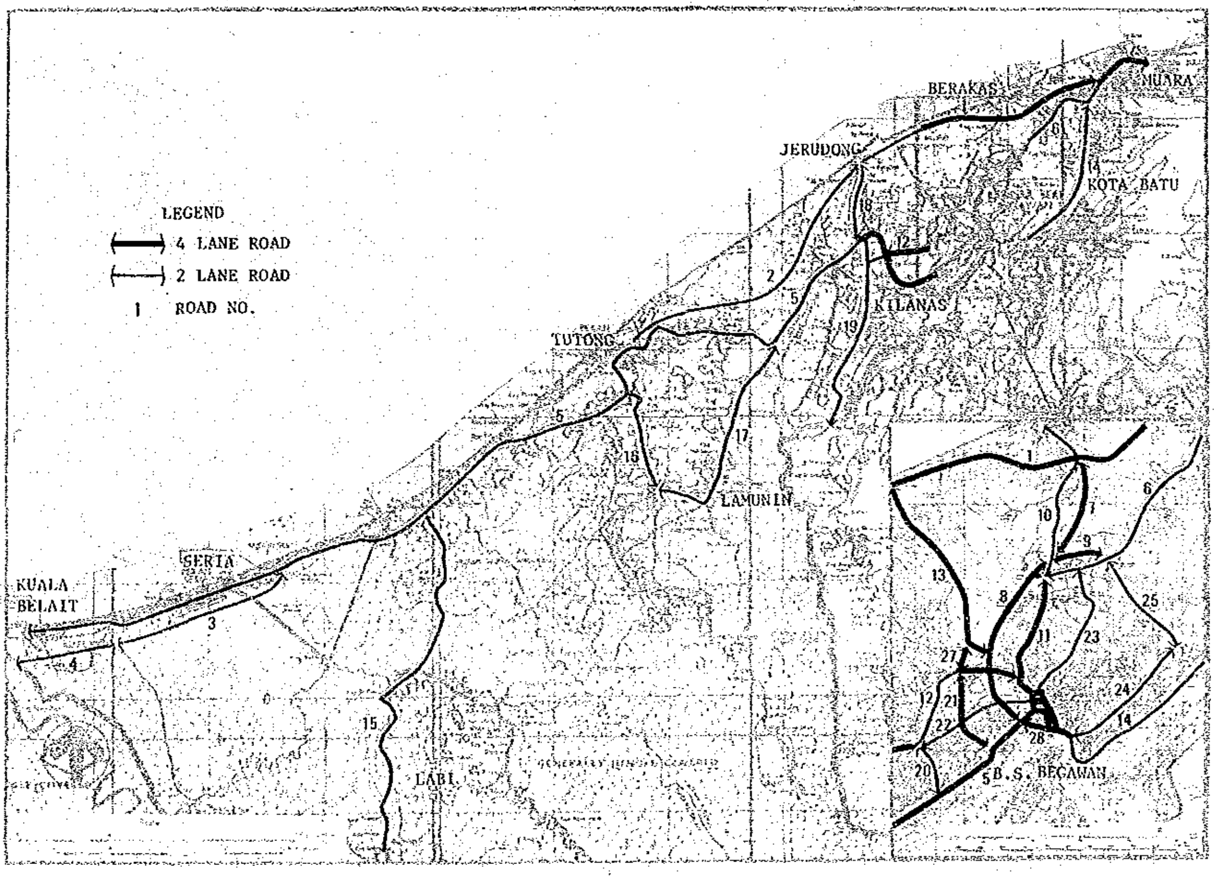


Fig. 5-2 Road Network (Alternative 1)

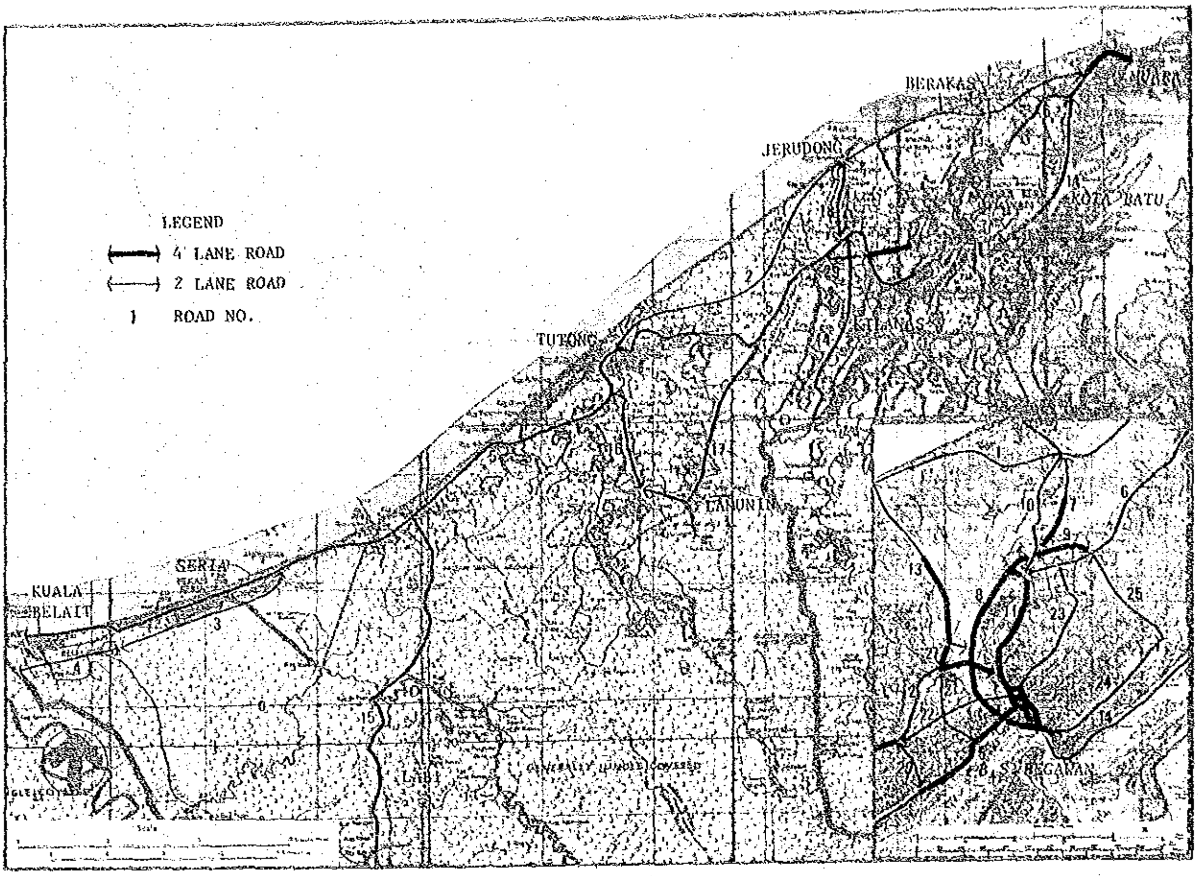


Fig. 5-3 Road Network (Alternative 2, 3)

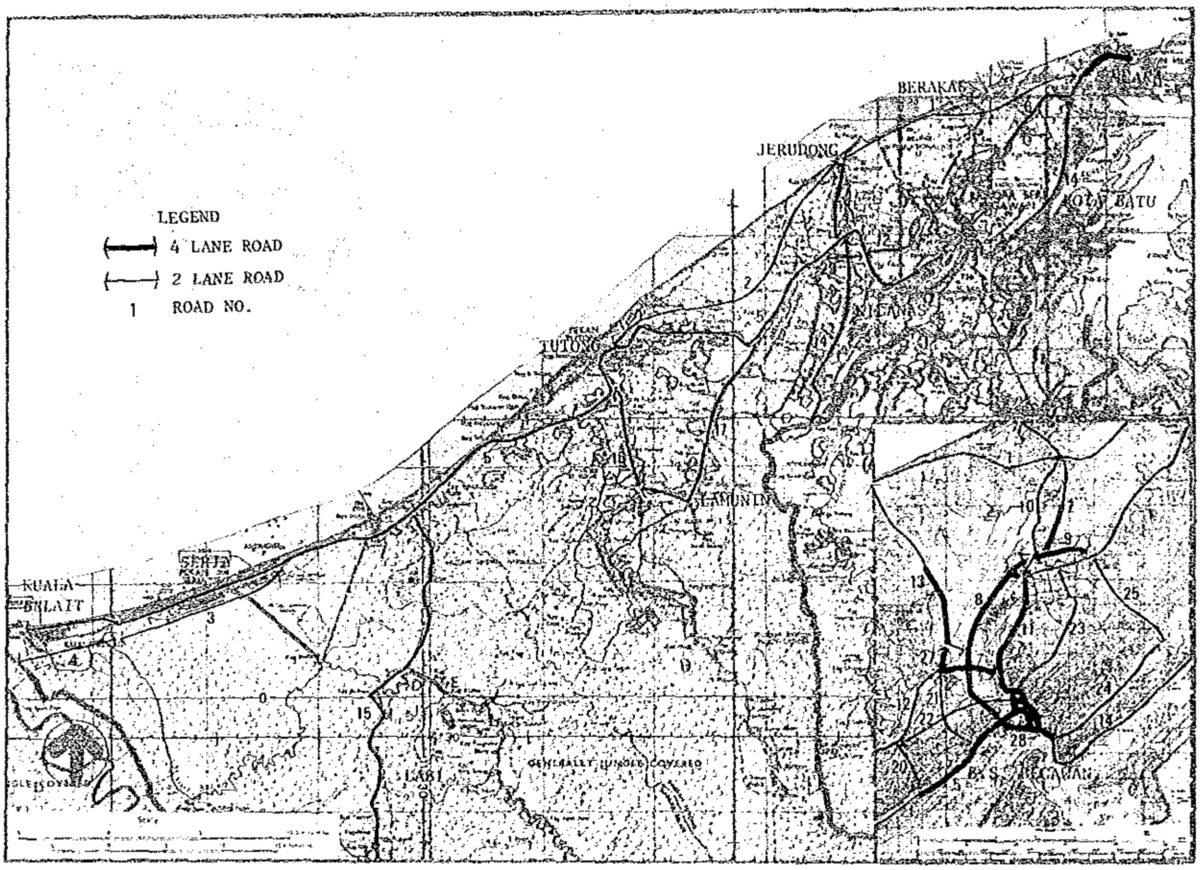


Fig. 5-4 Road Network (Alternative 4)

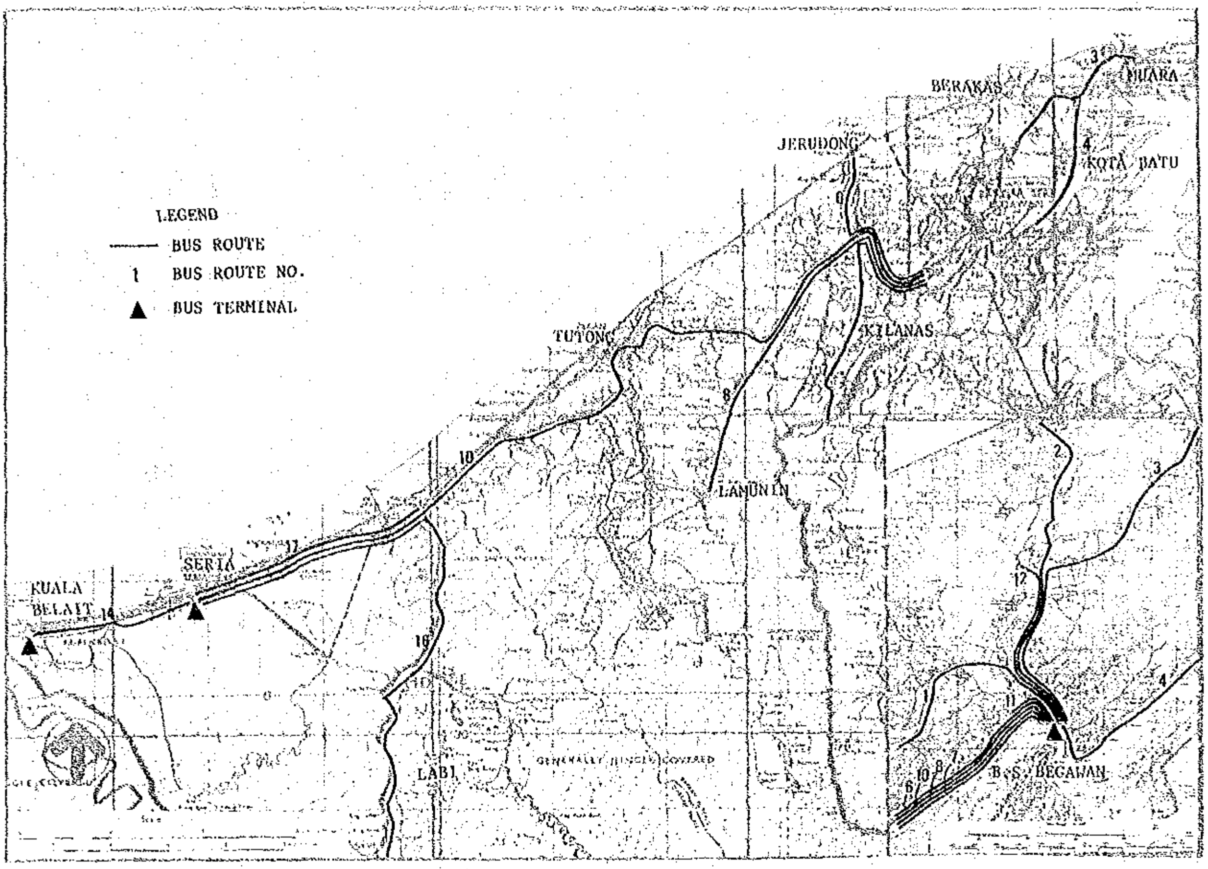


Fig. 5-5 Bus Network (Alternative 0, 1)

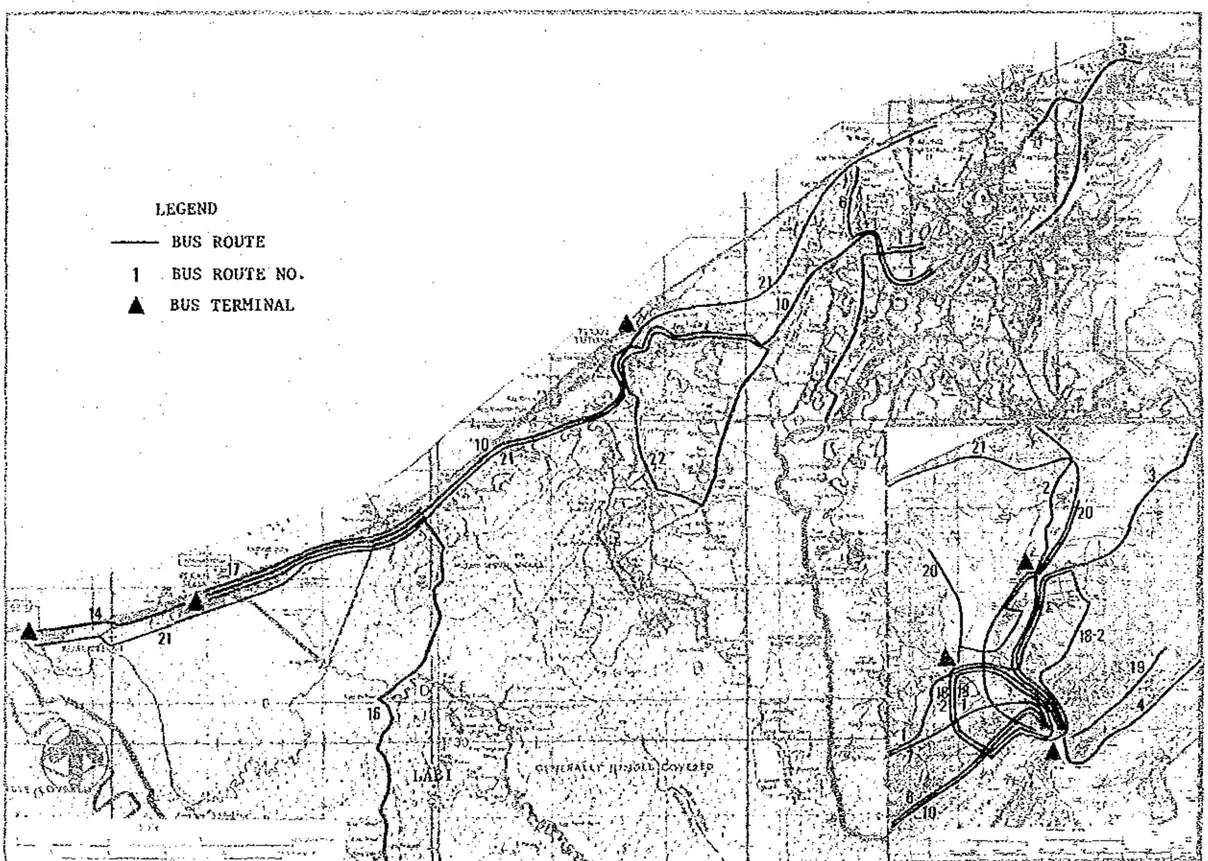


Fig. 5-6 Bus Network (Alternative 2, 3, 4)

Table 5-3 Level of Bus Services by Alternative Plans

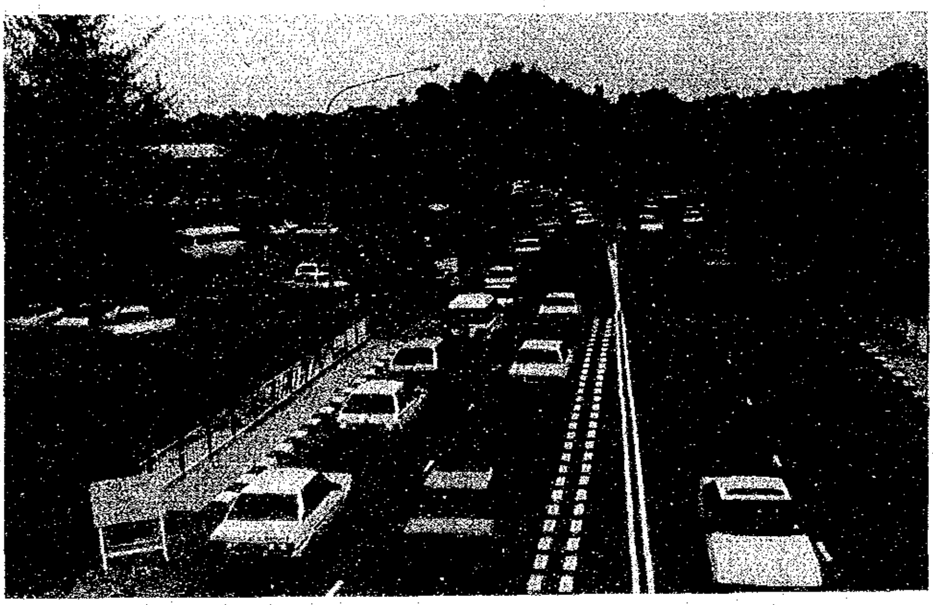
Route No.	Origin/Destination		Average Interval of Bus Departure			
			Alt. 0,1	Alt. 2	Alt. 3	Alt. 4
			Minutes	Minutes	Minutes	Minutes
1	B.S.B.	- Gadong	85	20	15	30
2	B.S.B.	- Berakas	37	10	20	30
3	B.S.B.	- Muara	40	10	10	20
4	B.S.B.	- Kota Batu	50	10	15	20
5	Sungai Kebun	- Lumapas	-	-	-	-
6	B.S.B.	- Jerudong	142	20	30	60
7	B.S.B.	- Limau Manis	136	20	30	60
8	B.S.B.	- Lamunin	-	-	-	-
9	B.S.B.	- Tutong	-	-	-	-
10	B.S.B.	- Seria	26	10	10	20
11	B.S.B.	- Hospital	80	-	-	-
12	B.S.B.	- Airport	52	-	-	-
13	Tutong	- Tutong Camp	-	-	-	-
14	K.B.	- Seria	23	5	10	10
15	K.B.	- Miri	90	-	-	-
16	Seria	- Labi	60	20	20	60
17	Seria	- Sugai Liang	-	20	30	60
18-1	B.S.B.	- Gadong	-	10	-	-
18-2	B.S.B.	- B.S.B.	-	10	10	20
19	B.S.B.	- Subok	-	20	30	30
20	Lambak	- Rimba	-	5	10	20
21	B.S.B.	- K.B.	-	20	30	60
22	Tutong	- Lamunin	-	20	30	60
	Average		48	12	17	27

Table 5-4 Number of Lanes by Alternative Plans

Road No.	Road Name	Alt. - 0		Alt. - 1		Alt. - 2,3		Alt. - 4	
		Function 1/	No. of Lanes	Function 1/	No. of Lanes	Function 1/	No. of Lanes	Function 1/	No. of Lanes
1	Muara/Jerudong Coastal	A	2	A	4	A	2	A	2
2	Jerudong/Tutong Coastal	A	2	A	2	A	2	A	2
3	Seria Bypass	A	2	A	2	A	2	A	2
4	Sungai Tujoh Road	A	2	A	2	A	2	A	2
5	Jln. Tutong Seria	A	2	A	2	A	2	A	2
6	Jln. Muara	A	2, Partly 4		2, Partly 4	A	2, Partly 4	A	2, Partly 4
7	Berakas Link	A	2	A	4	A	2, Partly 4	A	2, Partly 4
8	Major Arterial Road I	A	4	A	4	A	4	A	4
9	Major Arterial Road II	A	4	A	4	A	2	A	2
10	Jln. Berakas	B	2	B	2	B	2	B	2
11	Jln. Kubang Pasang	B	4	B	4	B	4	B	4
12	Jln. Gadong	B	2, Partly 4	B	4, Partly 2	B	2, Partly 4	B	4, Partly 2
13	Tungku Link Road	B	2	B	4	B	2, Partly 4	B	2, 4
14	Jln. Kota Batu	B	2	B	2, Partly 4	B	2, Partly 4	B	2, 4
15	Jln. Labi	C	2	C	2	C	2	C	2
16	Tanjong Maya Road	C	2	C	2	C	2	C	2
17	Jln. Lamunin	C	2	C	2	C	2	C	2
18	Jln. Jerudong	C	2	C	2	C	2	C	2
19	Jln. Mulaut/Masin	C	2	C	2	C	2	C	2
20	Tutong Berakas Link	D	2	D	2	D	2	D	2
21	Kiarong Link	D	2	B	4	D	2	D	2
22	SG. Kedayan Radial Road	D	2	D	2	D	2	D	2
23	Jln. Kebangsaan	D	2	D	2	D	2	D	2
24	Jln. Subok	D	2	D	2	D	2	D	2
25	Subok Mangis Link	D	2	D	2	D	2	D	2
26	Major Arterial Road III	-	-	A	4	A	4	A	4
27	Tungku Gadong Link	-	-	B	4	B	4	B	4
28	Mulaut Link	-	-	-	-	A	2	A	2

1/ A : Inter-City Arterial Road
B : Intra-City Arterial Road
C : Regional Distributor
D : Intra-City Distributor

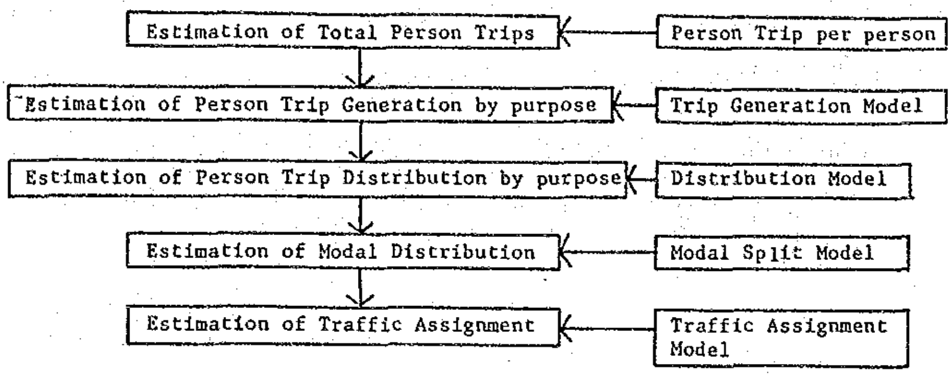
CHAPTER 6 TRANSPORT DEMAND FORCAST



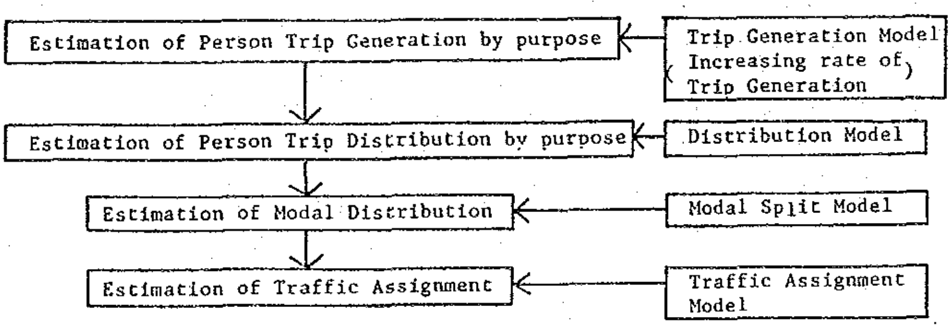
CHAPTER 6 TRANSPORT DEMAND FORCAST

6-1 Methodology and Procedures

Estimation of traffic volume by the person trip method is usually made in the following process. (Four stage or five stage estimation method)



As the purpose of the survey conducted this time is establishment of a public transport improvement program, and this program covers the entire Brunei, it is not necessary to include transportation modes such as walking and bicycles which are not competitive with public means of transport. Therefore, because of the fact that the present OD tables were produced based on the survey conducted with automotive vehicles and buses as the target, the process from generated traffic volume to person trip generation and attraction is partly different from that with usual person trip method. The process used this time is indicated below.



6-2 Definitions and Trip Purpose Stratification

(1) Trip purpose stratification

Trip purpose stratification used for the forecast is same as that used in the survey, and is as follows.

① Work
② Business
③ Home
④ School
⑤ Others

(2) Trip mode stratification

The trip mode stratification used for the forecast is as follows.

		(Trip mode stratification used in the survey)
Buses	Public buses	Public buses
	School buses	School buses
Automotive vehicles	Passenger cars, etc	Passenger cars, taxies
	Goods vehicles	Vans, pickups, tracks

Of these trip modes, goods vehicles are excluded from the objects of modal split because the way of their use is different from that of passenger cars and conversion to public buses cannot be highly anticipated. With goods vehicles, therefore, estimation is made in the category of all purposes (VT base). By taking into due consideration the above, the concrete process of estimation of traffic volume is established as shown in Fig. 6-1.

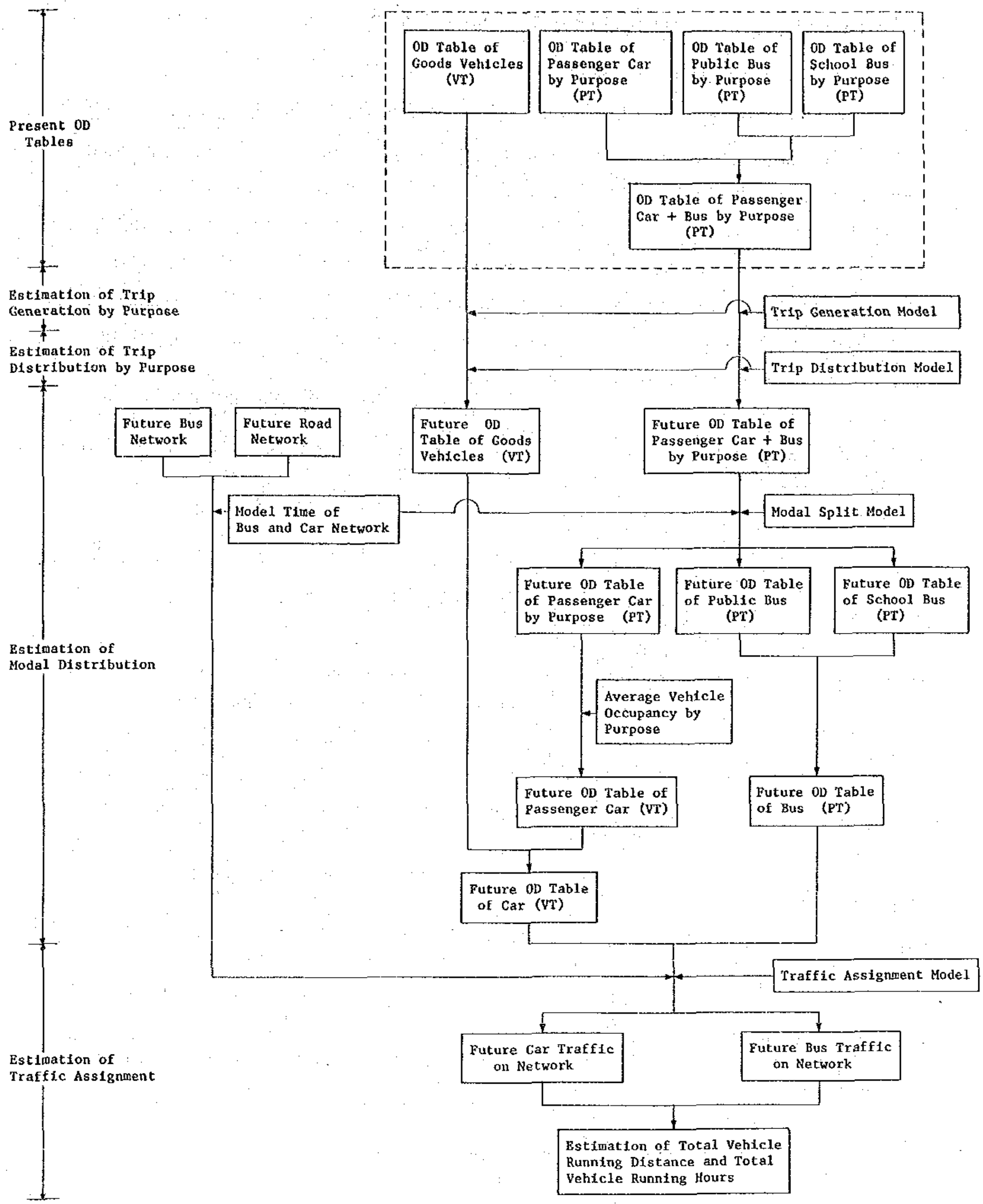


Fig. 6-1 Estimation Process of Traffic Volume

6-3 Person Trip Generation and Attraction

6-3-1 Person trip generation and attraction

The present OD tables, which are the basis for estimation of traffic volume, do not include all of person trip generation and attraction in each zone. It is therefore difficult to estimate the total value of person trip generation and attraction in each zone by using the general method of the person trip generation and attraction model. Therefore, the person trip generation and attraction by zone in the future is computed by multiplying the growth rate of person trip generation and attraction of each zone to the present person trip generation and attraction by purpose. The following indexes are used for the person trip generation and attraction growth rate by purpose.

Table 6-1 Estimation Indexes For Generation and Attraction of Future Person Trip

		Generation	Attraction
Passenger cars, etc. + buses (PT)	Work	Night time population growth rate	Day time population growth rate
	Business	Day time population growth rate	Day time population growth rate
	Home	Day time population growth rate	Night time population growth rate
	School	Night time population growth rate	Day time population growth rate
	Others	Day time population growth rate	Day time population growth rate
Goods vehicles (VT)		Day time population growth rate	Day time population growth rate

* Future person trip generation (attraction) by purpose and zone = Present person trip generation (attraction) by purpose and zone × Index for estimation of person trip generation and attraction by purpose and zone.

6-3-2 Forecast of trip generation and attraction

The person trip generation and attraction by purpose estimated using population index by zone is shown in Table 6-2.

Table 6-2 Forecast of Number of Trips by Purpose

		1984		1995		Growth rate 1995/1984
		Number	Component ratio	Number	Component ratio	
Passenger cars + buses	Work	52,977	27.1	95,530	26.6	1.80
	Business	16,117	8.2	32,260	9.0	2.00
	Home	63,042	32.2	112,215	31.3	1.78
	School	11,804	6.0	18,924	5.3	1.60
	Others	51,823	26.5	99,699	27.8	1.92
	Total	195,764	100.0	358,598	100.0	1.83
Goods vehicles		24,751		49,476		2.00

* Internal trips in zone are not included in the number of trips.

The total number of trips by passenger cars and buses in 1995 is estimated as about 1.8 times, and the growth rates of trips for business and for other purposes are large. The number of trips by goods vehicles is estimated as about 2 times.

Table 6-3 Comparison of Person Trip Attraction by Zone and Purpose between Present and Future (Passenger Cars + Buses PT)

	Present 1984						Future 1995					
	Work	Business	Home	School	Others	Total	Work	Business	Home	School	Others	Total
11	15,031	4,985	7,240	2,057	16,262	45,576	17,890	6,696	9,131	2,381	21,309	57,407
12	477	138	1,812	532	717	3,675	620	203	2,283	628	1,028	4,762
13	1,367	116	1,015	3,206	861	6,565	1,779	171	1,467	3,897	1,233	8,547
14	1,648	281	2,374	981	1,506	6,789	3,030	582	5,872	2,766	3,051	15,301
15	3,576	2,507	3,122	533	6,093	15,831	5,598	4,427	5,921	1,131	10,482	27,559
16	592	154	1,286	0	747	2,778	637	188	1,330	0	885	3,040
17	230	62	1,188	122	102	1,705	229	69	1,100	125	112	1,635
*10	22,920	8,244	18,037	7,432	26,287	82,919	29,783	12,336	27,104	10,928	38,100	118,251
21	2,361	584	4,395	111	1,287	8,739	5,157	1,439	6,986	204	3,087	16,873
22	6,619	1,153	4,796	1,518	3,771	17,857	8,768	1,723	7,931	2,328	5,522	26,272
23	514	146	1,627	241	560	3,088	884	286	2,337	345	1,060	4,912
24	2,693	461	4,697	120	2,137	10,109	4,264	824	14,494	474	3,719	23,775
25	4,510	1,238	4,856	529	4,075	15,218	15,188	4,691	8,704	901	15,007	4,443
26	2,592	583	3,004	87	2,030	8,296	11,167	2,833	9,636	841	9,586	34,063
27	2,016	1,331	2,229	352	3,242	9,170	4,540	3,332	3,115	660	8,026	19,723
28	1,055	224	2,448	96	365	4,188	1,963	470	3,752	152	746	7,083
29	175	29	833	0	33	1,070	359	66	1,210	0	74	1,709
30	15	0	344	10	94	471	32	0	467	27	220	746
31	2,471	638	3,192	130	1,457	7,888	5,555	1,618	6,081	280	2,603	17,137
*2,3	25,028	6,388	32,421	3,204	19,052	86,094	57,877	17,332	64,713	6,212	50,650	196,784
41	1,860	683	3,800	126	2,759	9,228	2,901	1,186	6,319	204	4,626	15,236
42	2,326	569	4,189	318	3,131	10,533	3,602	984	6,295	555	5,234	16,670
43	163	49	726	0	197	1,135	273	90	1,816	0	357	2,536
*40	4,340	1,300	8,715	444	6,086	20,895	6,776	2,260	14,430	759	10,217	34,442
51	609	157	2,632	677	374	4,449	992	288	4,409	961	664	7,314
52	71	27	1,238	48	24	1,407	102	44	1,559	64	38	1,807
*50	670	184	3,870	725	398	5,856	1,094	332	5,968	1,025	702	9,121
61												
*60												
Total	32,977	16,117	63,042	11,804	51,823	195,764	95,530	32,260	112,215	18,924	99,669	358,598

Table 6-4 Comparison of Person Trip Generation by Zone and Purpose between Present and Future (Passenger Cars + Buses PT)

	Present 1984						Future 1995					
	Work	Business	Home	School	Others	Total	Work	Business	Home	School	Others	Total
11	9,308	2,630	13,990	806	8,793	35,527	11,835	3,119	16,775	884	10,677	43,290
12	459	439	738	0	616	2,253	584	569	967	0	819	2,930
13	1,314	82	3,106	123	917	5,541	1,915	106	4,072	150	1,217	7,460
14	1,271	506	1,558	507	11,110	4,953	3,170	926	2,888	1,068	2,081	10,133
15	4,073	961	5,320	1,030	3,861	15,246	7,789	1,499	8,390	1,664	6,154	25,496
16	077	372	580	311	342	2,381	1,019	400	631	275	375	2,700
17	906	18	368	116	824	2,233	843	18	370	93	839	2,163
*10	18,308	5,009	25,661	2,893	16,464	68,334	27,155	6,637	34,093	4,134	22,162	94,181
21	2,777	1,161	1,070	834	2,553	8,394	4,440	2,522	2,354	1,123	5,678	16,131
22	6,509	2,019	8,222	864	6,776	24,390	10,849	2,661	10,973	1,217	9,161	34,861
23	2,130	329	1,772	166	1,800	6,197	3,084	562	3,070	202	3,151	10,069
24	4,570	686	2,835	862	3,901	12,854	14,218	1,080	4,523	2,264	6,282	23,367
25	4,835	1,872	4,987	1,101	4,917	17,712	8,735	6,252	16.882	1,680	16,757	50,306
26	2,599	1,220	2,681	1,025	2,998	10,524	8,405	5,227	11,637	2,801	13,135	41,205
27	3,120	530	2,860	993	2,062	8,564	2,987	1,188	6,487	1,182	4,729	16,573
28	807	325	957	700	820	3,610	1,249	602	1,793	914	1,561	6,119
29	96	221	57	242	162	778	140	451	117	299	339	1,346
30	151	22	118	66	190	547	207	47	257	76	415	1,002
31	2,924	1,125	1,858	873	2,038	8,818	5,614	2,514	4,206	1,415	4,667	18,416
*2,3	29,517	9,510	27,417	7,727	28,216	102,387	59,937	23,106	62,299	13,178	65,375	224,395
41	2,008	714	4,080	85	3,015	9,902	3,395	1,125	6,451	109	4,909	15,989
42	1,905	675	4,062	121	2,976	9,739	2,906	1,060	6,386	159	4,823	15,334
43	165	30	274	233	210	912	419	51	463	446	363	1,742
*40	4,078	1,419	8,415	439	6,200	20,553	6,720	2,236	13,300	714	10,095	33,065
51	852	129	1,429	113	750	3,273	1,489	206	2,349	161	1,253	5,411
52	221	50	120	633	193	1,217	279	72	174	737	284	1,546
*50	1,073	179	1,340	746	943	4,490	1,718	28	2,523	898	1,537	6,957
61												
*60												
Total	52,977	16,117	63,042	11,804	51,823	193,764	95,530	32,260	112,215	18,924	99,669	358,593

6-4 Trip Distribution

6-4-1 Trip distribution model

Future OD tables by purpose can be estimated using the forecasted future person trip generation and attraction by purpose and zone. Development of a number of business areas and residential areas is in progress at the present time around B.S.B. It is considered that the land use pattern will change to a certain extent by 1995, and a sign of changes to the transportation pattern which accompany said change has already appeared in the present OD tables. It is therefore considered that such a basic pattern of transportation will not make a major change until the target year, i.e., 1995. It is therefore decided to use the "present pattern method" also for the trip distribution model. The method of computation is the "Flator method".

6-4-2 Forecast of trip distribution

The forecasted future desire lines by purpose are shown in Fig. 6-2. It is indicated for each purposes that attraction of trips to Gadong and Berakas, which is found to minor extent in the present situation, is further accelerated and that these areas, as sub center, will become important places of generation and attraction of person trips.

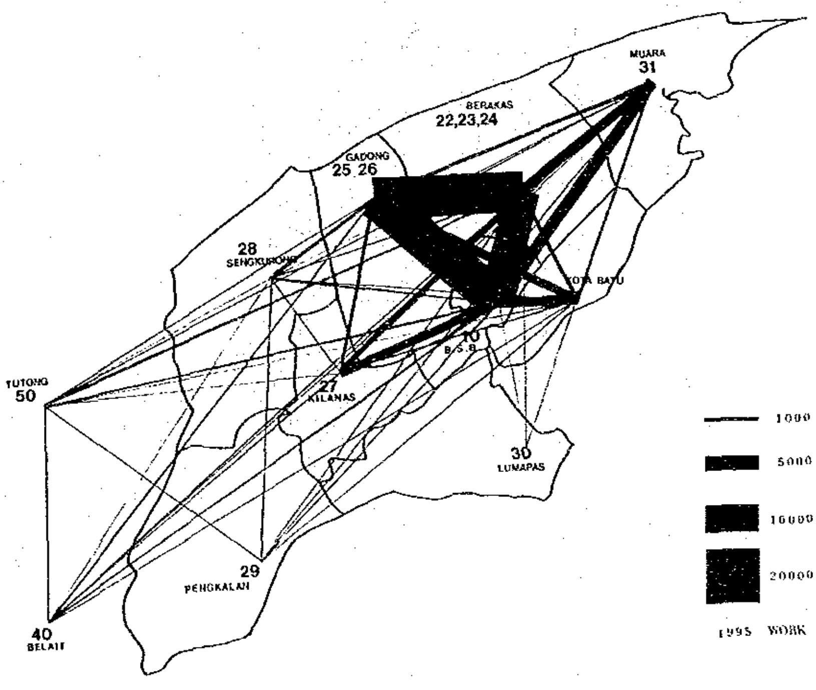
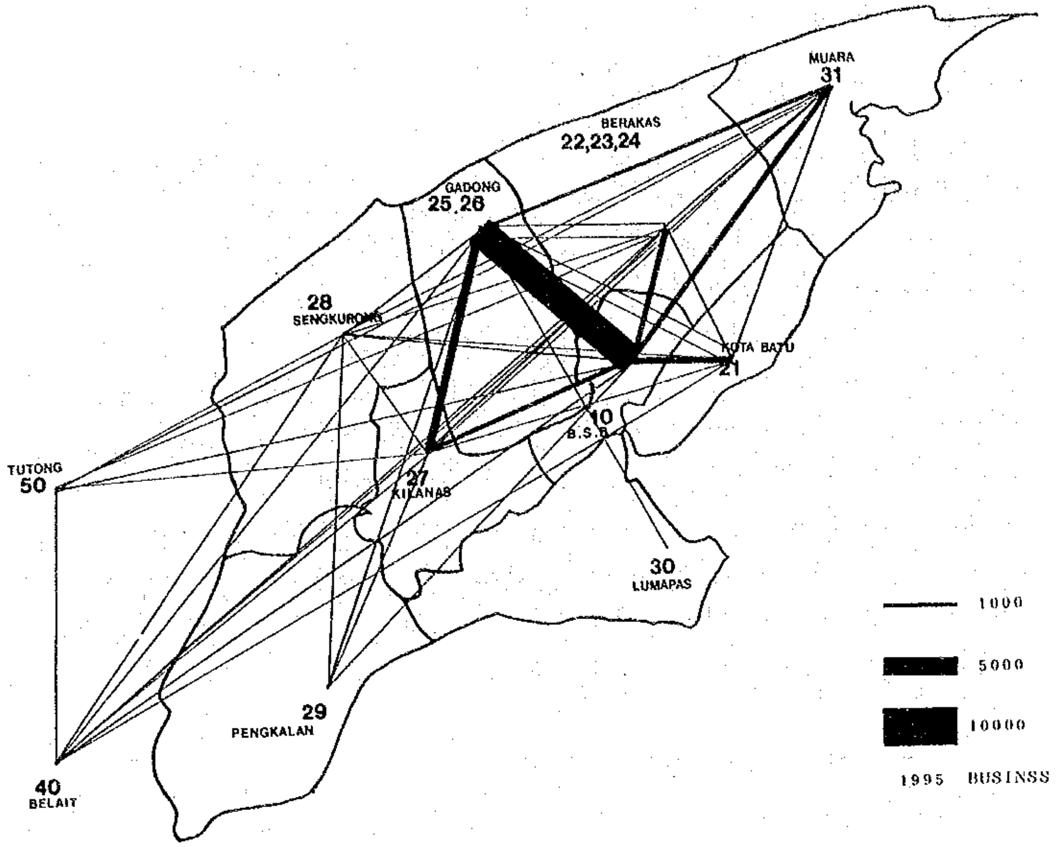


Fig. 6-2 Future Desired Lines by Purpose



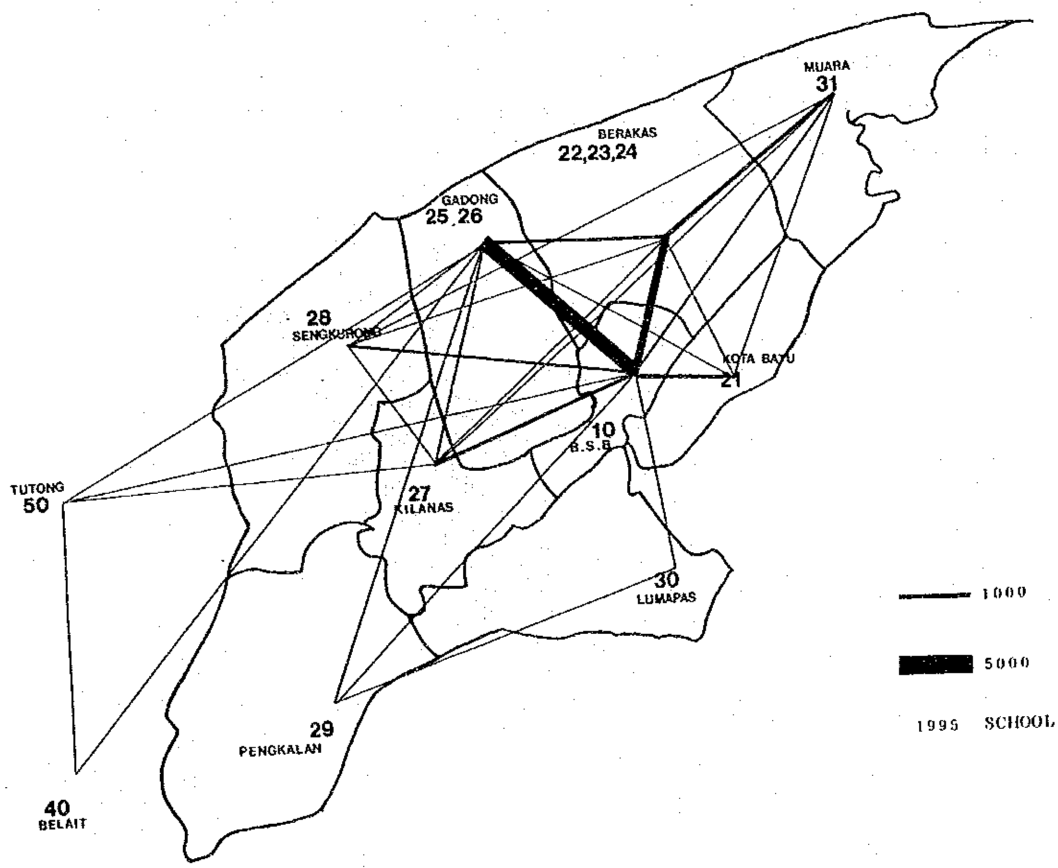


Fig. 6-2 Future Desired Lines by Purpose

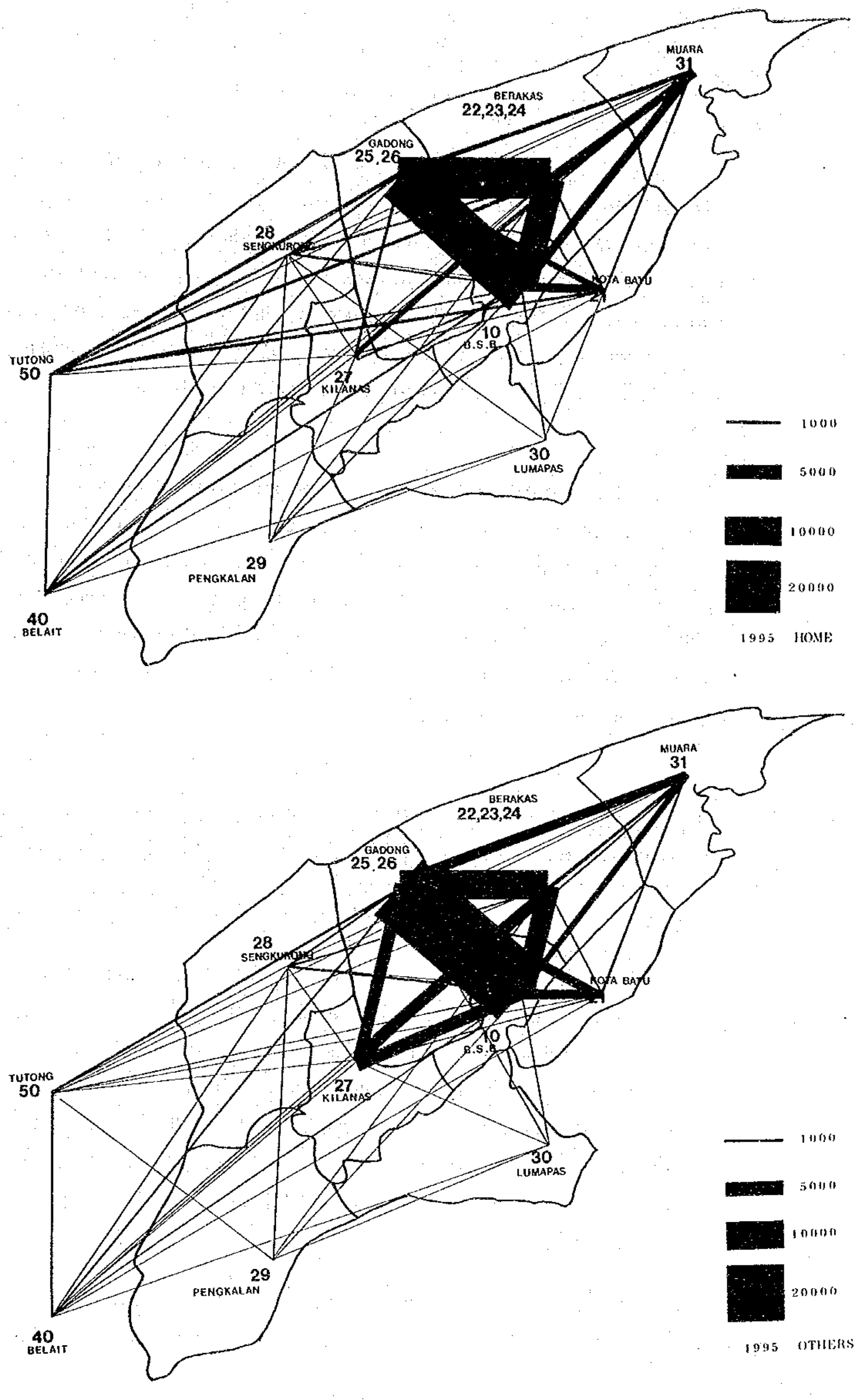


Fig. 6-2 Future Desired Lines by Purpose

6-5 Modal Split

6-5-1 Modal split model

(1) Establishment of modal split model

The future OD tables by purpose forecasted with trip distribution models is split into bus OD tables and passenger car OD tables by modal split models. Each OD pair trip distribution is multiplied by bus and passenger car modal split ratios, and number of trips of each of buses and passenger cars is computed. The modal split ratio of each OD pair is estimated by a modal split model. (Fig. 6-3)

It is considered that the modal split ratios to buses and passenger cars between 0 and D is determined in general by the level of supply of each modes of transport. The travel time between 0 and D of each of passenger cars and buses is selected as the index that indicates the supply level, and the relation between supply level and modal ratio is considered as follows.

$$\text{Modal split ratio of buses between 0 and D} = \left(\frac{\text{Number of trips of buses}}{\text{Number of trips of buses and passenger cars}} \right) = F\left(\frac{\text{Travel time required by passenger car between 0 and D}}{\text{Travel time required by bus between 0 and D}} \right)$$

The relation between two variables is expressed as a curve with the modal split ratio taken along the vertical axis and travel time ratio taken along the horizontal axis. This curve is called a modal split line. The trend of selection of the mode of transport is varied by the purpose of trip. It is therefore necessary to analyze the relation between travel time ratio and modal split ratio as classified by purpose.

The relation between modal split ratio and travel time ratio of the current situation can be shown as indicated in

Fig. 6-4 by making use of the present OD tables by purpose and mode and the travel time required between O. and D. on the model networks.

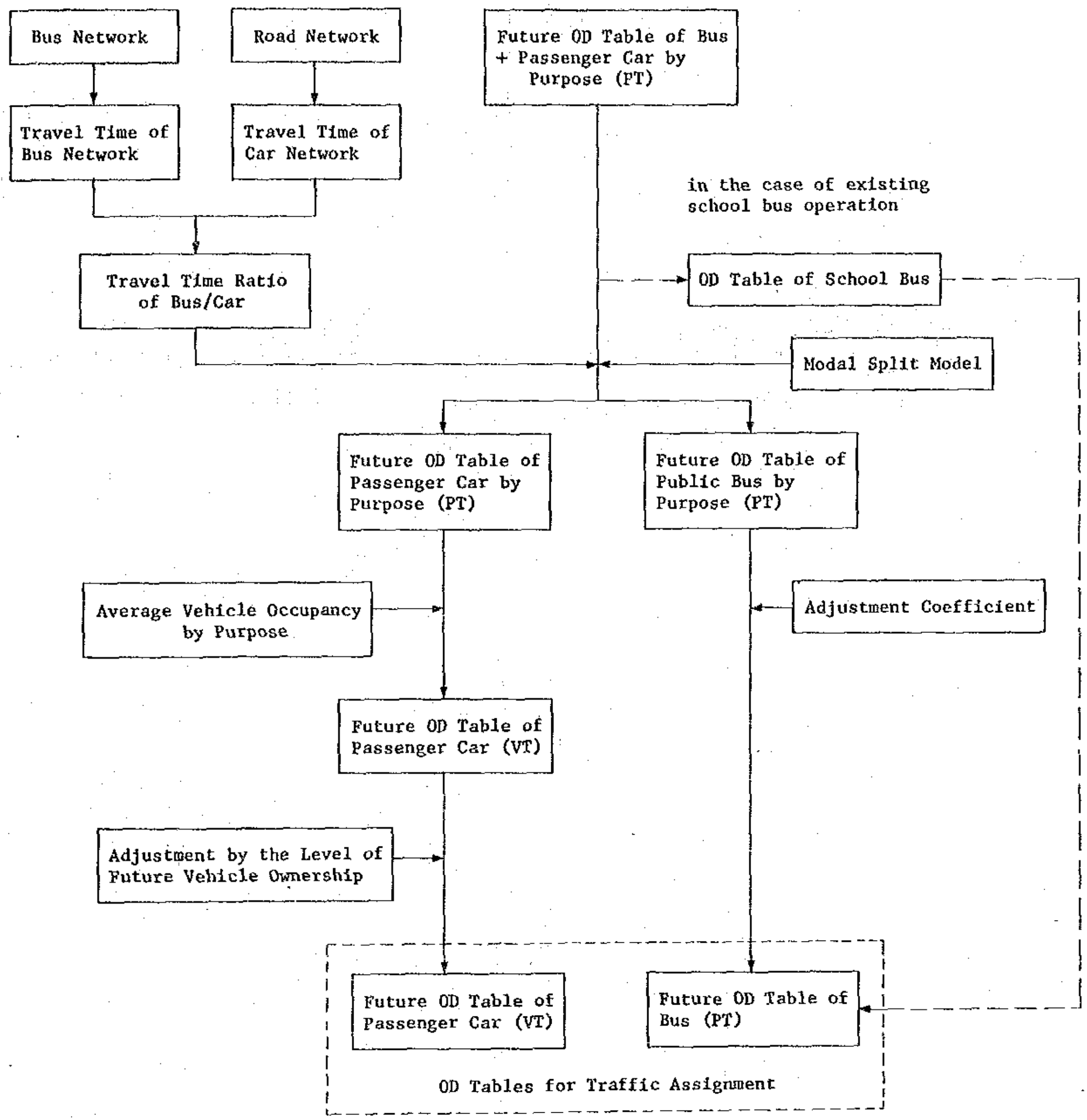


Fig. 6-3 Estimation Process of Trips by Means

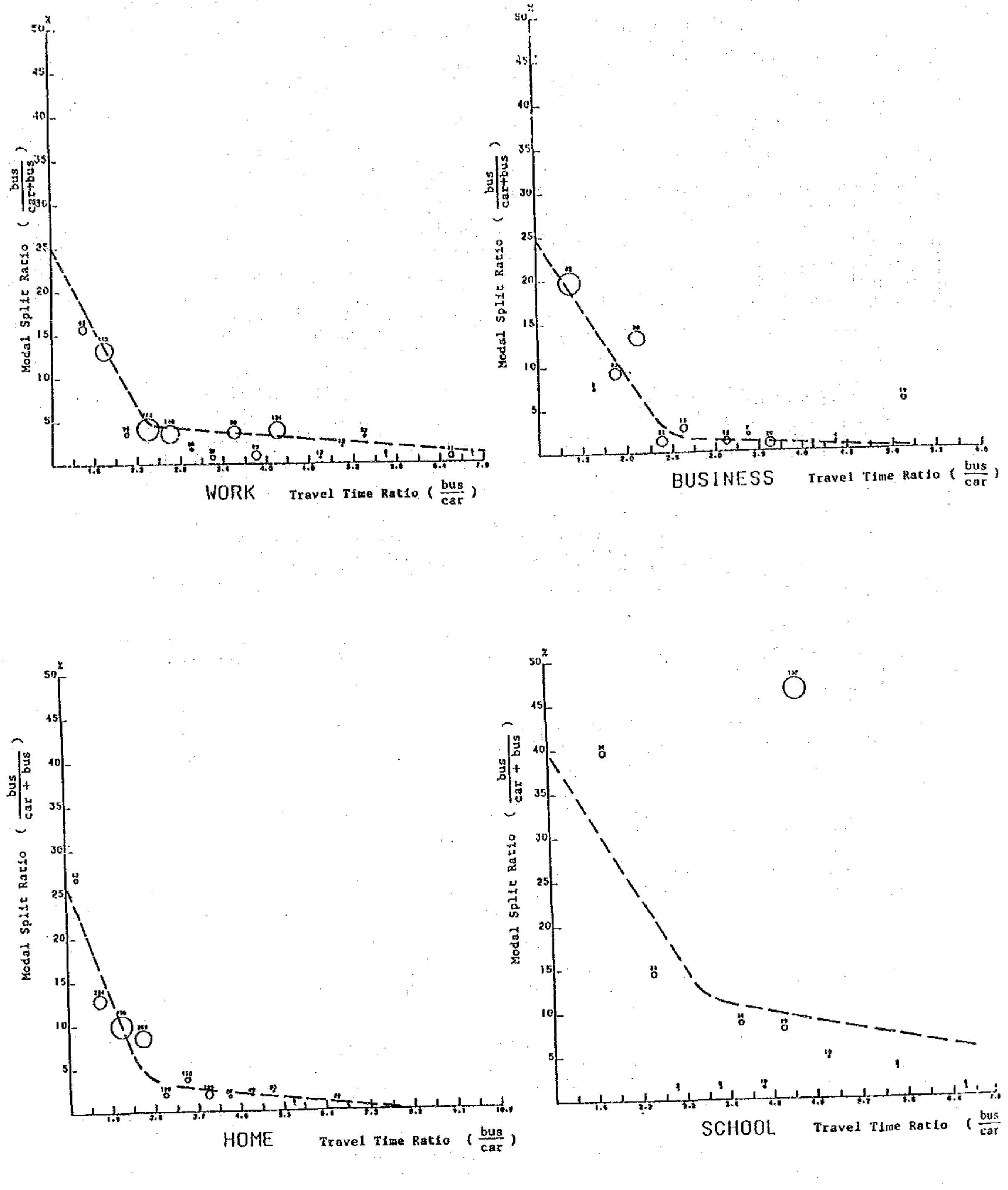
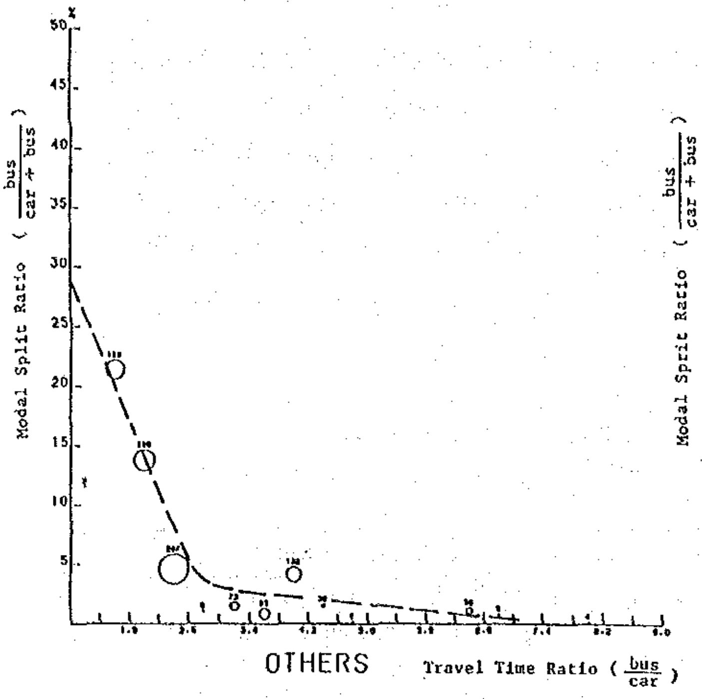
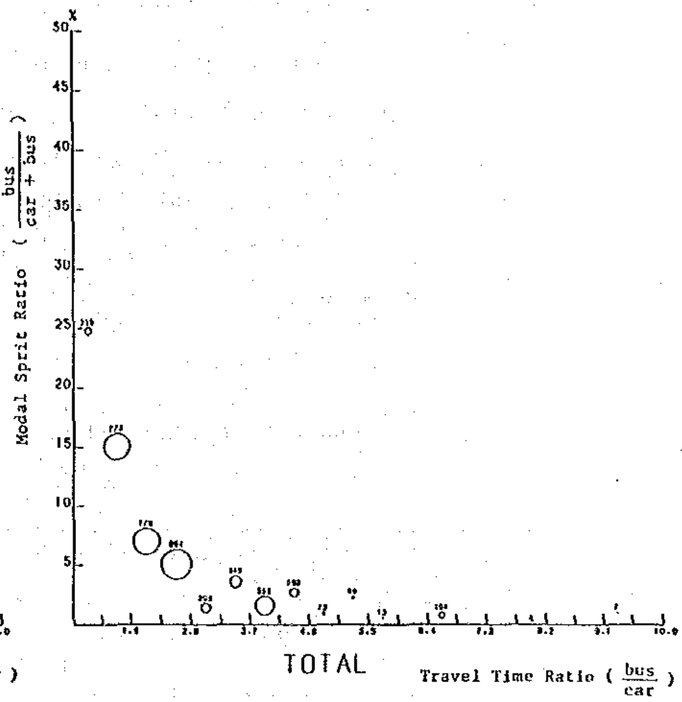


Fig. 6-4 Split Line by Purpose





Accordingly, the bus/car modal split line is set as shown in Fig. 6-5.

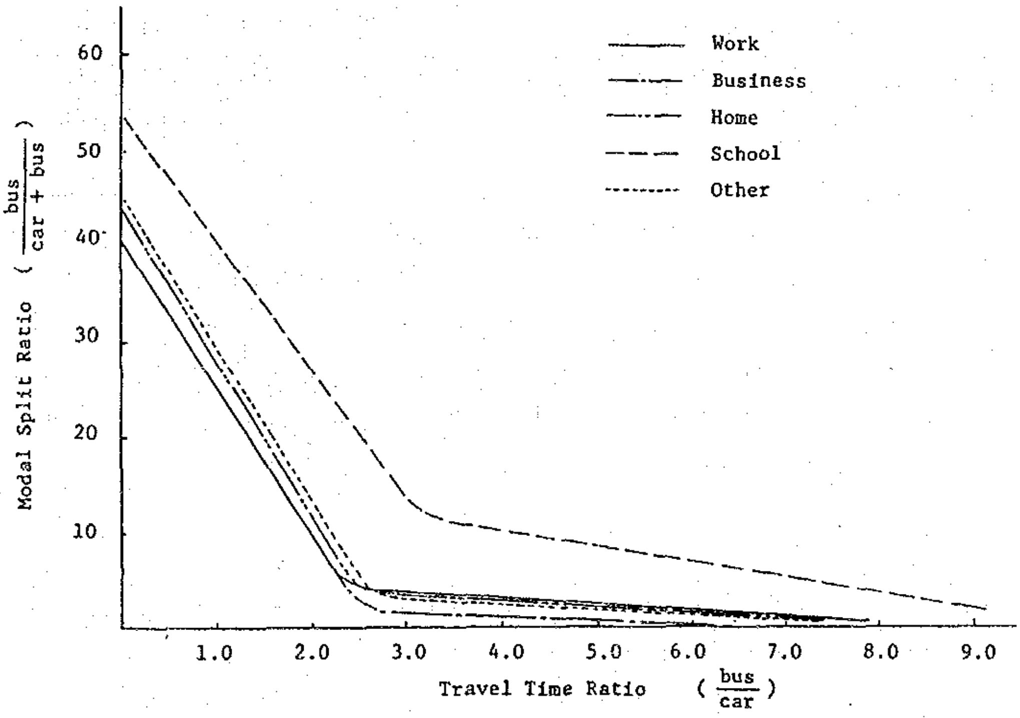


Fig. 6-5 Modal Split Line

(2) Examination of accuracy of modal split model

In order to examine the accuracy of the set split lines, present OD table by trip mode is estimated using model networks and modal split models. A comparison between surveyed present number of trips by purpose and trip mode and number of trips estimated from models is shown in Table 6-5.

Table 6-5 Result of Estimation of Present Number of Trips by Purpose and Trip Mode

	Passenger cars			Public buses		
	Present	Estimated	Ratio ··· Estimated /Result	Present	Estimated	Ratio ··· Estimated /Result
Work	47,387	46,796	0.988	1,380	1,971	1.428
Business	14,546	14,433	0.992	261	373	1.429
Home	51,879	51,530	0.993	(6,845) 2,475	(7,194) 2,824	(1.051) 1.141
School	6,316	6,076	0.962	(4,816) 446	(5,056) 686	(1.050) 1.538
Others	46,484	45,698	0.983	1,378	2,164	1.570
Total	166,610	164,533	0.988	(14,682) 5,942	(16,758) 8,018	(1.141) 1.349

Some estimation differences are found in a number of trip purposes as shown above. Therefore, the forecast of trips by purpose and trip mode is adjusted by the correction factor, that is, the ratio between estimated value and present value of the number of trips by purpose indicated in the above table.

(3) Correction by car holding level

Expected improvements in the road and bus networks are reflected in the above curves of split ratio. Furthermore, changes in the car holding level should also be reflected in the split ratio. In order to satisfy this purpose, the following correction factor is used as a multiplier for the number of trips of each car OD pair estimated by the split line.

$$\text{Correction factor} = \frac{\left(\dfrac{\text{Future total number of cars holdings}}{\text{Present total number of cars holdings}}\right)}{\left(\dfrac{\text{Future total number of trips}}{\text{Present total number of trips}}\right)}$$

In this case, the correction factor is determined in the case where travelling of cars is the most advantageous, and the same value is applied to other alternative network.

(4) Conversion passenger car traffic

The estimated passenger car OD table by purpose is divided by average number of passenger car occupancy by purpose, and conversion is made from person trip OD table to vehicle trip OD table for traffic assignment.

The average number of passenger car occupancy by purpose to be used is shown in Table 6-6.

Table 6-6 Average Number of Passenger Car Occupancy by Purpose

Purpose	Work	Business	Home	School	Others	Total
Mean number of persons per one passenger car	1.7	1.5	1.9	2.1	1.9	1.8

6-5-2 Forecast of trip distribution by transportation

The Modes estimated trip distribution by purpose and transportation mode of Alternative 0, which is the base case, and of set four alternatives are shown in Table 6-8, and each growth of number of trips by trip mode are shown in Table 6-7. Each alternative indicates a different trip split ratio in correspondence to the service levels of buses and roads of each alternative. With Alternative 2 of the highest bus service level, the bus split ratio is estimated of 21.6% and trip growth rate from the present value is estimated 12 times.

Table 6-7 Growth of Number of Trips by Trip Mode

			Buses			Passen-ger cars	Goods vehicles (VT)
			Public buses	School buses	Total		
1984		Number	5,942	8,741	14,683	181,012	24,571
		Growth rate	1.00	1.00	1.00	1.00	1.00
1995	Alt-0	Number	19,857	8,741	28,598	310,990	36,904
		Growth rate	3.34	1.00	1.95	1.72	1.49
	Alt-1	Number	16,392	8,741	25,133	315,579	36,904
		Growth rate	2.76	1.00	1.71	1.74	1.49
	Alt-2	Number	71,048	0	71,048	257,662	36,904
		Growth rate	11.96	0.00	4.84	1.42	1.49
	Alt-3	Number	61,448	0	61,448	269,600	36,904
		Growth rate	10.34	0.00	4.18	1.49	1.49
	Alt-4	Number	37,043	0	37,043	307,854	36,904
		Growth rate	6.23	0.00	2.52	1.70	1.49

Table 6-8 Result of Estimation of Trip Distribution by Purpose and Transportation Mode (after correction)

		1984		1995									
				Alt-0		Alt-1		Alt-2		Alt-3		Alt-4	
		Number	Ratio of transport mode	Number	Ratio of transport mode	Number	Ratio of transport mode	Number	Ratio of transport mode	Number	Ratio of transport mode	Number	Ratio of transport mode
Work	Public buses	1,380	2.6	4,525	5.0	3,736	4.1	15,147	17.5	12,906	14.8	7,824	8.4
	Passenger cars	51,197	97.4	85,792	95.0	86,876	95.9	71,177	82.5	74,261	82.5	84,340	91.5
	Total	52,977	100.0	90,317	100.0	90,612	100.0	86,324	100.0	87,167	100.0	92,164	100.0
Business	Public buses	261	1.6	1,115	3.6	922	3.0	5,042	17.3	4,290	14.6	2,488	8.0
	Passenger cars	15,856	98.4	29,545	96.4	29,810	97.0	24,138	82.7	25,174	85.4	28,705	92.0
	Total	16,117	100.0	30,660	100.0	30,732	100.0	29,180	100.0	29,464	100.0	31,193	100.0
Home	Public buses	2,475	3.9	7,583	7.0	6,353	5.9	27,120	25.2	23,302	21.6	13,874	12.6
	School bus	4,370	6.9	4,370	4.1	4,370	4.1	0	0.0	0	0.0	0	0.0
	Passenger cars	56,197	89.1	95,552	88.9	96,904	90.0	80,600	74.8	84,467	78.4	96,336	87.4
	Total	63,042	100.0	107,505	100.0	107,627	100.0	107,720	100.0	107,769	100.0	110,210	100.0
School	Public buses	446	3.8	1,698	9.6	1,410	7.9	6,871	37.9	6,335	34.9	3,396	19.9
	School bus	4,370	37.0	4,370	24.8	4,370	24.6	0	0.0	0	0.0	0	0.0
	Passenger cars	6,988	59.2	11,562	65.6	11,987	67.5	11,254	62.1	11,797	65.1	13,674	80.1
	Total	11,804	100.0	17,630	100.0	17,769	100.0	18,125	100.0	18,132	100.0	17,070	100.0
Others	Public buses	1,378	2.7	4,936	5.3	3,971	30.6	16,868	19.3	14,615	16.5	9,461	10.0
	Passenger cars	50,445	97.3	88,541	94.7	9,000	69.4	70,493	80.7	73,900	83.5	84,800	90.0
	Total	51,823	100.0	93,477	100.0	12,971	100.0	87,361	100.0	88,515	100.0	94,261	100.0
Total	Public buses	5,942	3.0	19,857	5.8	16,392	4.8	71,048	21.6	61,448	18.6	37,043	10.7
	School bus	8,741	4.5	8,741	2.6	8,741	2.6	0	0.0	0	0.0	0	0.0
	Passenger cars	181,012	92.5	310,990	91.6	315,579	92.6	257,662	78.4	269,600	81.4	307,854	89.3
	Total	195,764	100.0	339,588	100.0	340,712	100.0	328,710	100.0	331,018	100.0	344,897	100.0

The relation between the number of bus operation and number of trips making use of buses, whch is an index that indicates the service level of buses, is shown in Table 6-9. The incremental bus trip induced by the increased of bus operation is indicated by the number of increased number of bus passenger trips per bus operation added to the base case. (Fig. 6-6) It is understood from this figure that the operation plan of Alternative 3 provides the highest induction effect.

Table 6-9 Bus Trip Increasing Effect by Increase of Bus Operation

	Number of bus operation	Number of trips using public buses	Number of bus operation added to Alt-0	Number of of trips increased from Alt-0	Number of increased trips per added bus operation
Alt-0	319	19,857	-	-	-
Alt-1	319	16,392	0	-3,465	0
Alt-2	2,340	71,048	2,021	51,191	25.3
Alt-3	1,530	61,448	-1,211	41,591	34.3
Alt-4	920	37,043	601	17,186	28.6

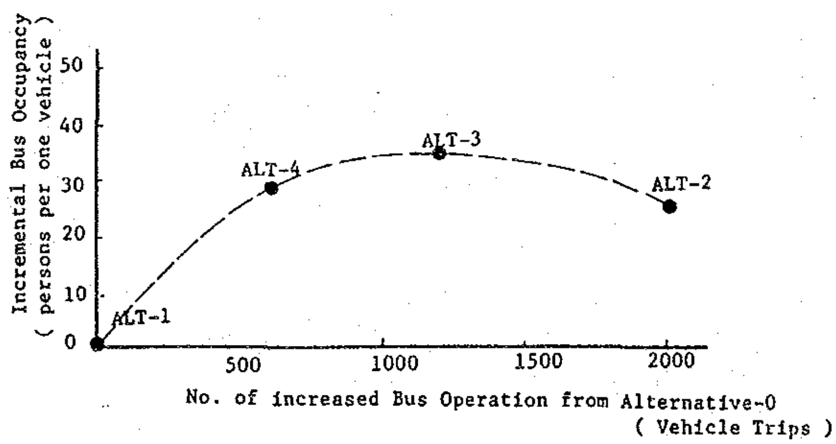


Fig. 6-6 Bus Trip Increasing Effect by Increase of Bus Operation

6-6 Traffic Assignment

6-6-1 Traffic assignment model

Traffic assignment is made in order to examine the traffic demand on the networks of established alternatives. The method for assignment is called practical assignment, where the travelling routes are determined with the situation of congestion of roads taken into account. The process of assignment is shown in Fig. 6-7.

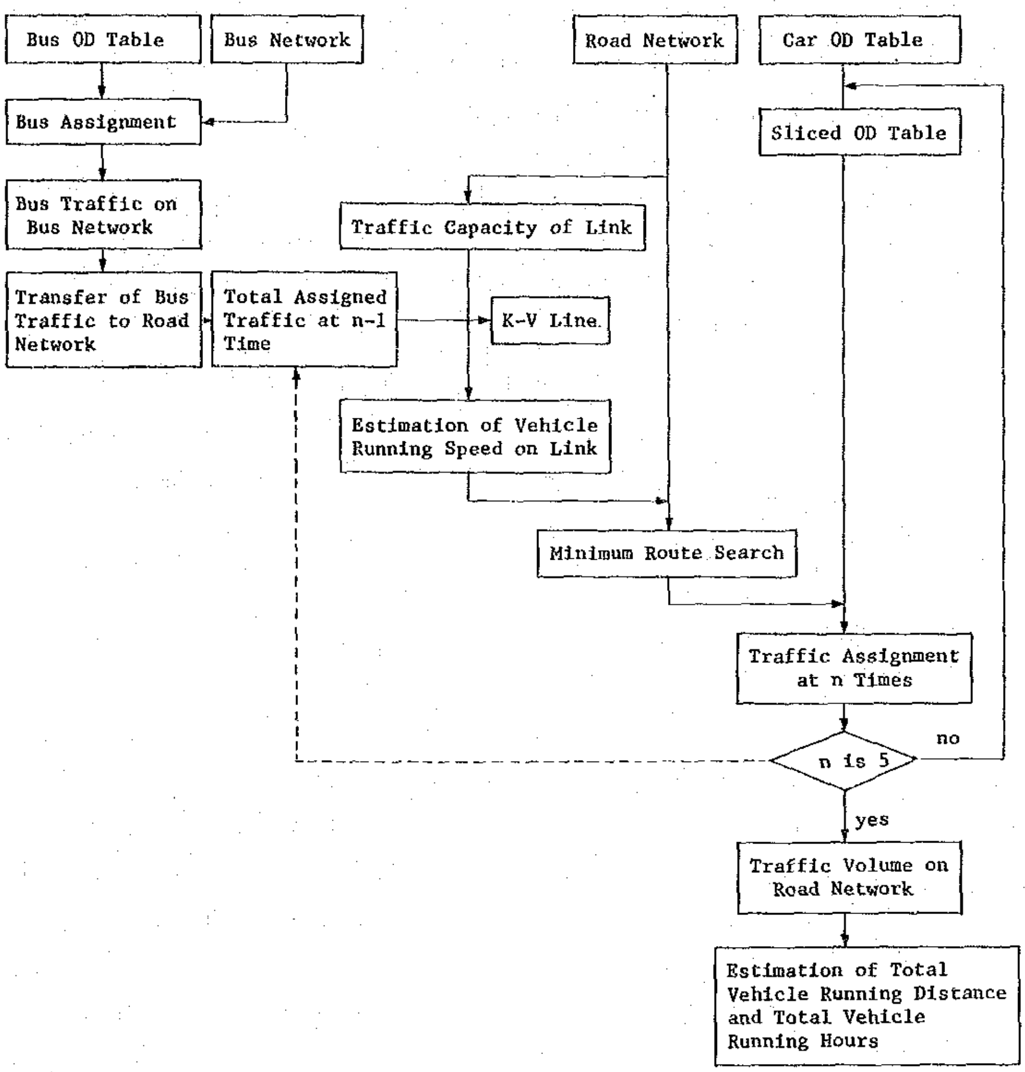
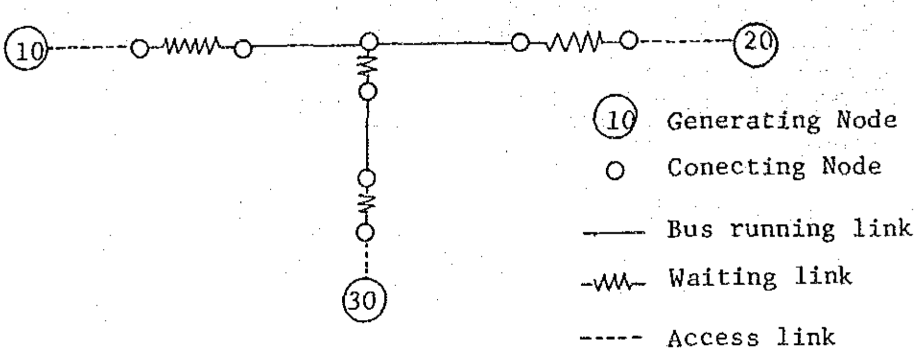


Fig. 6-7 Process of Traffic Assignment

(1) Establishment of bus network

A bus network is composed of three elements, i.e., access links, waiting links and travel links as shown below. Of these elements, an access link is the length of time for walking to a bus stop, and its is determined based on the average walking distance to the bus stop. A waiting link is the length of time for waiting for a bus at a bus stop, and it is set in correspondence to the planned bus operating frequency (operation interval). A travel link is constituted in correspondence to a planned bus route, and the travelling speed on a travel link is determined by the congestion degree of the road.



(2) Establishment of road network

A road network is composed of Generating nodes, access links and travel links. A Generating node is the point at which the traffic in each zone is generating and attracting, and is located at the position that is assumed to the gravity center of the population of the zone. An access link indicates an average time that the traffic reaches a travel link as an arterial road, and the average time is given by the status of expansion of town area in each zone. A capacity and a K-V line are given to a travel link in order to reflect the actual travelling condition of a road.

a) Capacity

The capacity of each road of a network is computed with the following formula.

$$Q = B \times a \times b \times c \times d \times \frac{1}{e}$$

where; Q : Traffic capacity (cars per 12-hour period)

B : Basic traffic capacity (cars per hour)

a : Correction factor by mixture of large size vehicles

b : Correction factor by roadside conditions

c : Correction factor by grade separated intersection

1/e : Peak factor (traffic volume in peak hour/traffic volume per 12-hour period)

d : Correction factor by planning level

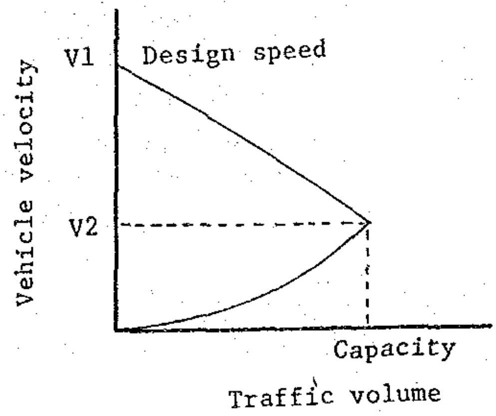
The traffic volume computed with the above formula is further rearranged by type and is simplified as shown in Table 6-10.

Table 6-10 Traffic Capacity of Each Link of Road Network (cars per 12-hour period)

	Road, 2 lanes	Road, 4 lanes	Road, 4 lanes (of which 2 lanes are exclusive bus lanes)	Expressway, 2 lanes	Expressway 4 lanes
Suburbs	14,000	50,000	25,000	14,000	50,000
Town area (general portion)	13,000	44,000	22,000	14,000	50,000
Town area (grade separated portion)	-	55,000	-	-	-
Central area	8,000	28,000	14,000	-	-
Central area (if, parking on the roads is excessive)	6,000	33,000	11,000	-	-

b) K-V line

The speed of a vehicle that travels along a road is related to the traffic volume. In general, when the traffic volume increases, the speed gradually decreases, and after the traffic volume reaches its capacity, the treatable traffic volume will be also decreased with the vehicle speed by a congestion. Such a relation can be indicated as a congestion-velocity curve (K-V line).



Travelling speed surveys were conducted at four places in order to set a suitable K-V line as matched with the realities of roads and travelling vehicles in Brunei.

The K-V line is established as shown in Fig.6-8 based on the results of these observations and with the enforced legal speed limit used as a reference.

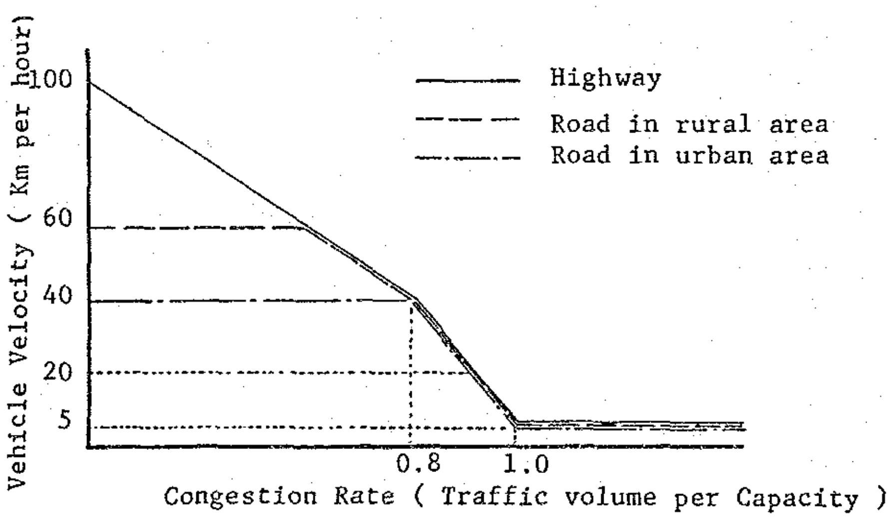


Fig. 6-8 K-V Line for Traffic Assignment

(3) Traffic assignment

Traffic assignment is made by the practical assignment method in order to reflect the practical situation of traffic congestion. Each OD pair traffic volume is assigned to links of the route of the shortest required time, but with the practical assignment method all OD pair traffic volumes are divided to 1/n and assignment is made by repeating n times. As the travelling speed at each assignment is determined with reference made to the K-V line based on the total value of traffic assigned up to the last time, jamming phenomenon which accompanies traffic congestion or round about of vehicles is reproduced.

In this estimation, the number of times of dividing is determined as equal 5 times.

① Bus asssignment

Public and school buses are assigned to the bus network on the PT base. After assignment, division is made by the average number of bus occupancy and conversion is made to number of buses.

② Car assignment

As for car assignment, the bus traffic volume converted into number of buses and car (passenger cars + goods vehicles) traffic volume split into five parts are assigned.

6-6-2 Forecast of future traffic volume

(1) Result of estimation of future traffic volume

The results of assignment of car traffic volume of Alternative 0, which is the base case, and of four established alternatives are shown in Fig. 6-9 through Fig. 6-18.

Principal indexes of each alternative based on traffic volume assignment are shown in Table 6-11.

Table 6-11 Results of Future Traffic Assignment by Alternatives (cars)

	Number of trips of cars (VT)	Capacity	Number of travelling cars	Average travelling distance	Average congestion degree
	1,000 trips	1,000 cars per km	1,000 cars per km	km	
Alternative 0	209	6,352	3,363	16.1	0.53
Alternative 1	212	8,672	3,240	15.3	0.37
Alternative 2	180	6,930	2,758	14.9	0.38
Alternative 3	186	6,930	2,856	15.0	0.41
Alternative 4	201	7,064	3,012	15.0	0.43

In the technical evaluation of the assigned traffic volume of each alternative, it is necessary that demand and supply of traffic are balanced, and for this purpose it is necessary that the congestion degree (= road traffic volume/road capacity) does not exceed 1.00 at any link. The outline of assigned traffic volume of each alternative is described below.

Alternative 0

The assigned traffic volume exceeds the capacity at many places in Brunei-Muara district. Congestion is particularly excessive at the town center of B.S.B. and radial roads surrounding of the town area. At the town center, the influence of the congestion is exerted over the area by the limitation of the capacity of the entrance roads. No congestion will occur in areas without Brunei-Muara district.

Alternative 1

Of places where congestion is observed with Alternative 0, congestion at the town center is solved because of provision of Major Arterial Road III. Furthermore, congestion of radial roads is also solved by increasing of their capacity. As a result, the road capacity is the largest among alternatives, and the average travelling distance and average congestion degree are the smallest, and thus a network of high service level is obtained.

Alternative 2

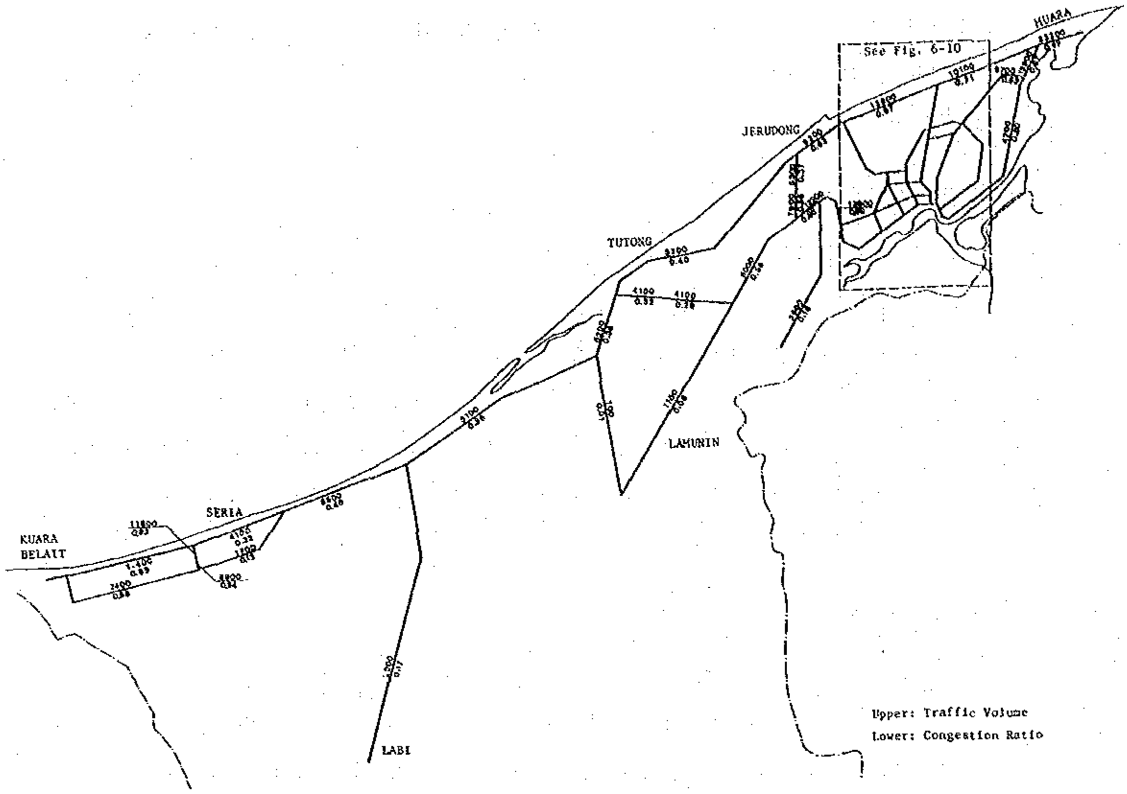
Traffic congestion along the radial roads, which occurred with Alternative 0, is solved by major conversion to bus utilization and increase of widths of some roads. Conversion of trip mode to bus utilization brought major reduction of number of travelling cars, and thus reduction of congestion degree is materialized with road provision that is less than that of Alternative 1.

Alternative 3

Conversion to buses is less compared to Alternative 2, but the car traffic volume is small. Accordingly, good balance between demand and supply is secured with the road section that is same as that of Alternative 2.

Alternative 4

The traffic congestion along radial roads is solved in a manner that is equal to that with Alternative 2 and 3. But conversion to bus utilization is not very large, and therefore, the extent of road congestion is slightly higher than that of Alternative 3.



Fi.g 6-9 Future Assigned Traffic (alternative-0) – 1

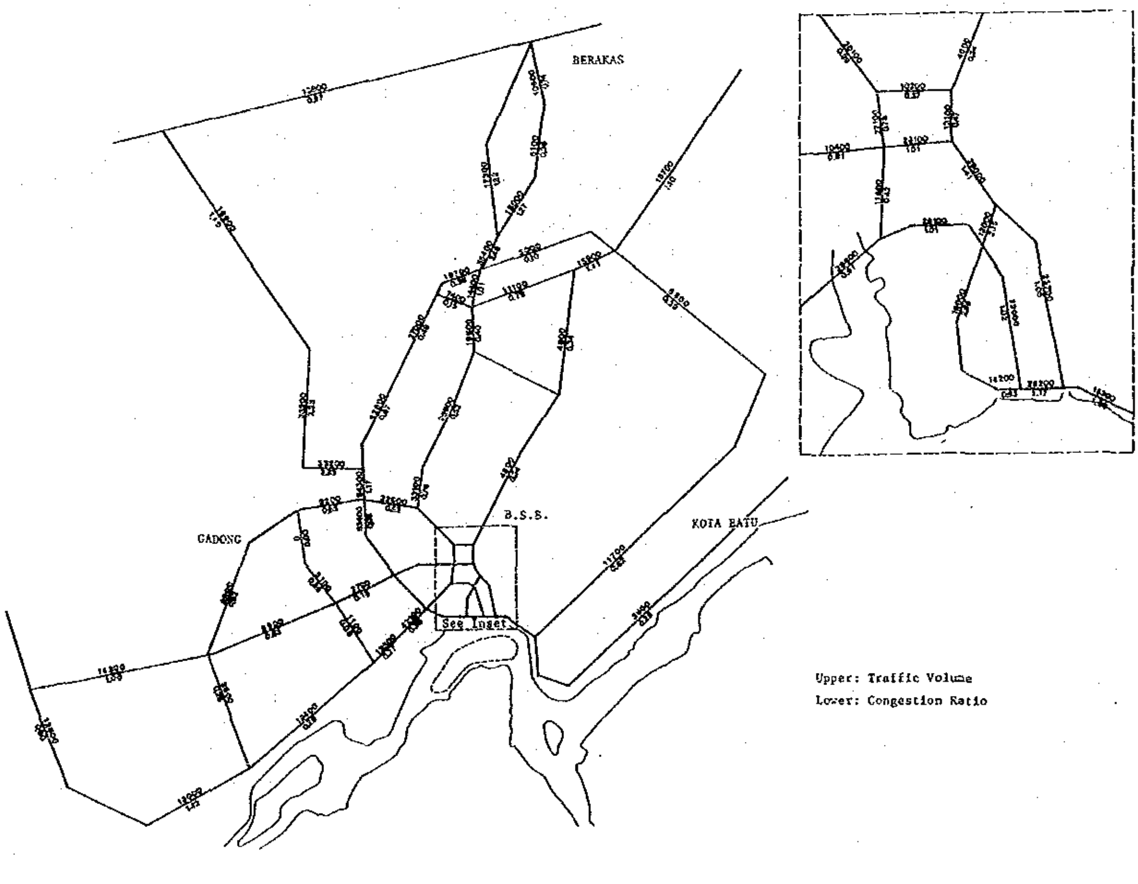


Fig. 6-10 Future Assigned Traffic (Alternative-0) – 2

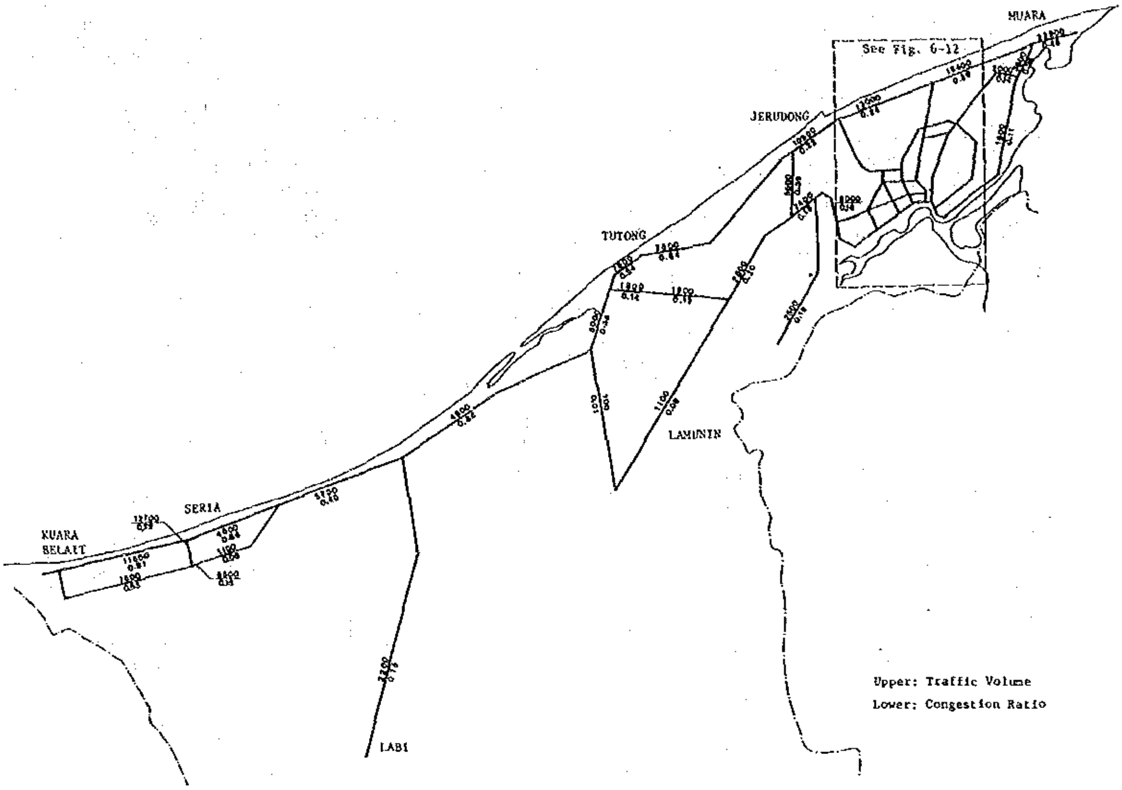


Fig. 6-11 Future Assigned Traffic (Alternative-1) – 1

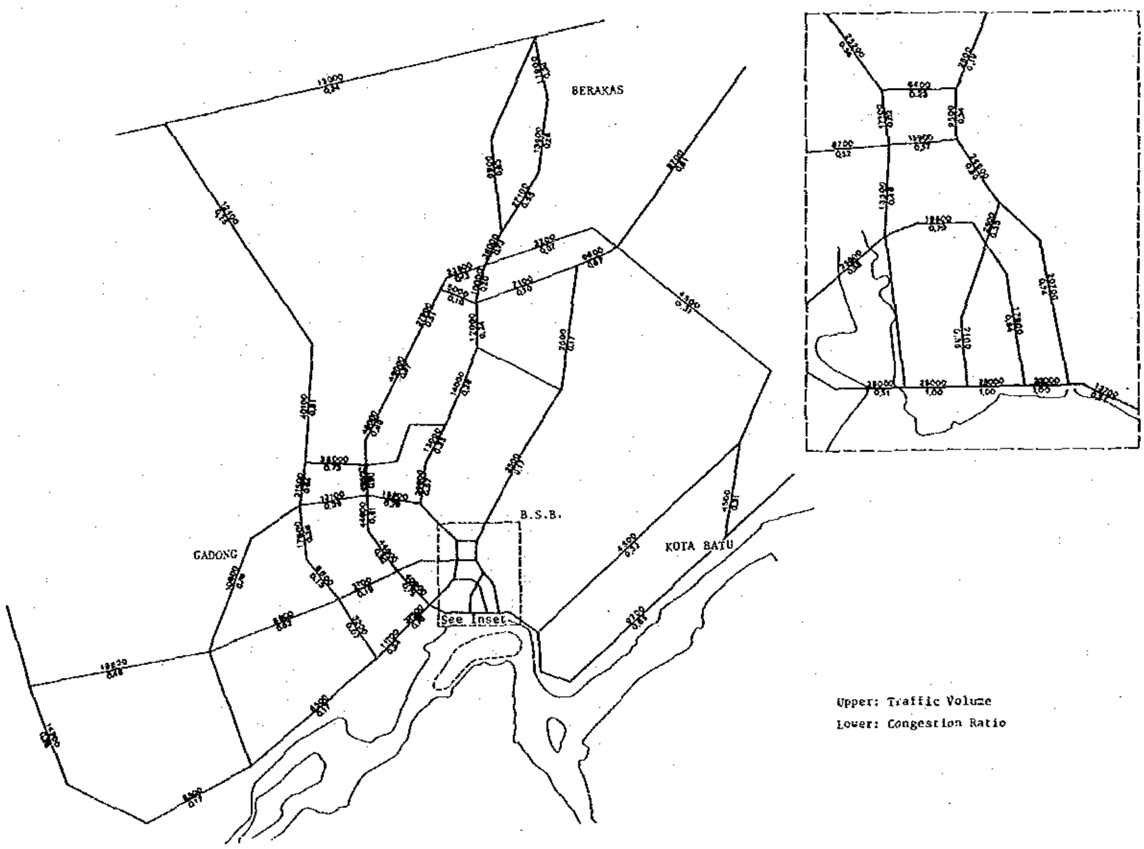


Fig. 6-12 Future Assigned Traffic (Alternative-1) – 2

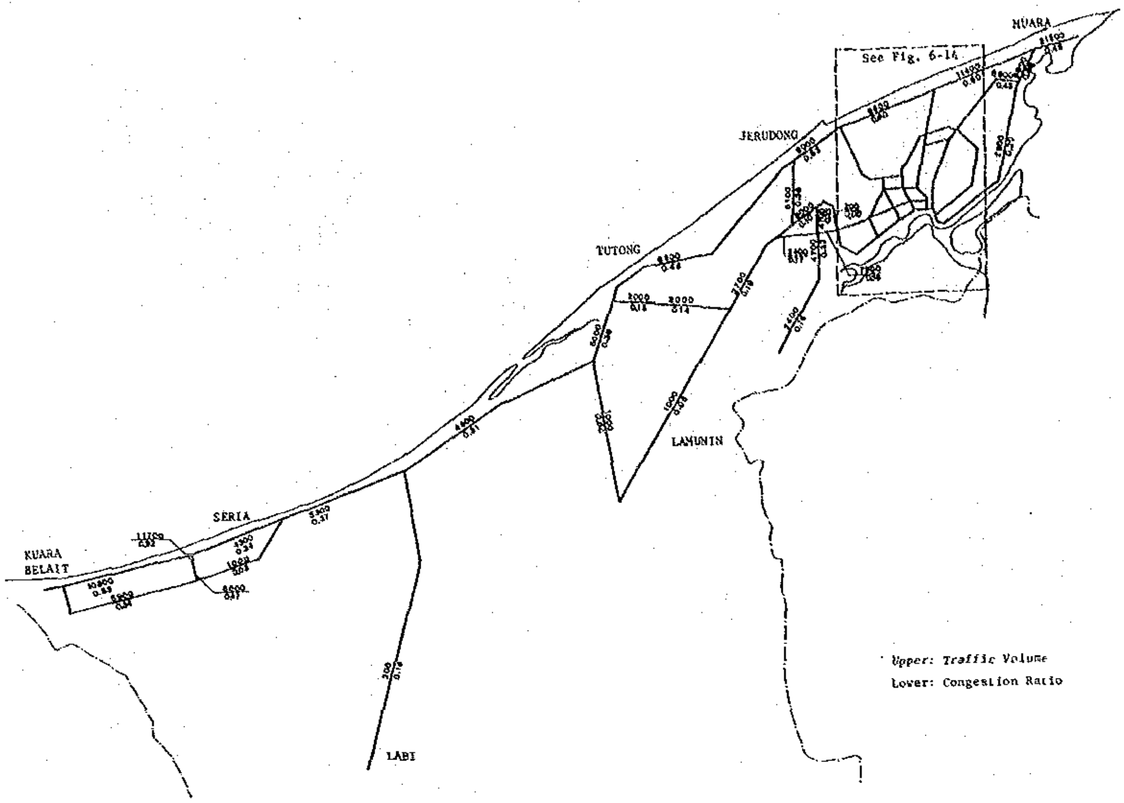


Fig. 6-13 Future Assigned Traffic (Alternative-2) – 1

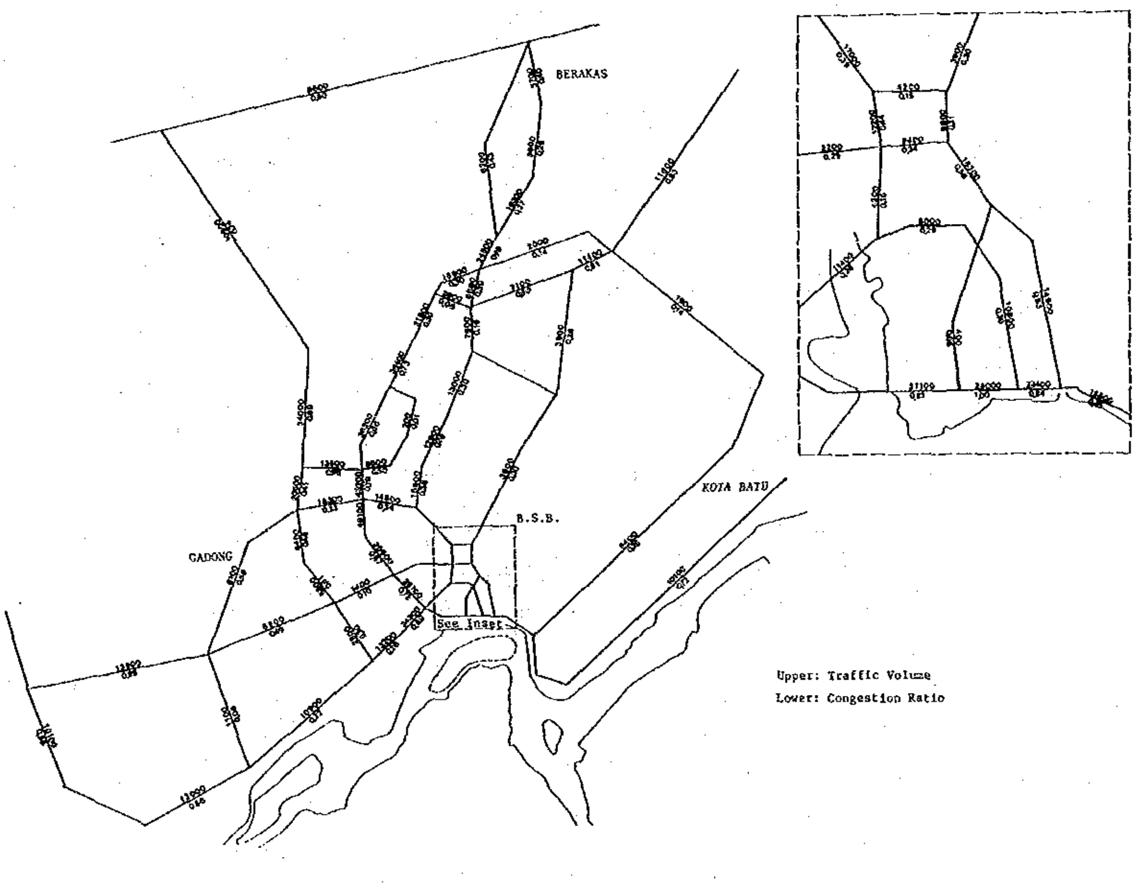


Fig. 6-14 Future Assigned Traffic (Alternative-2) – 2

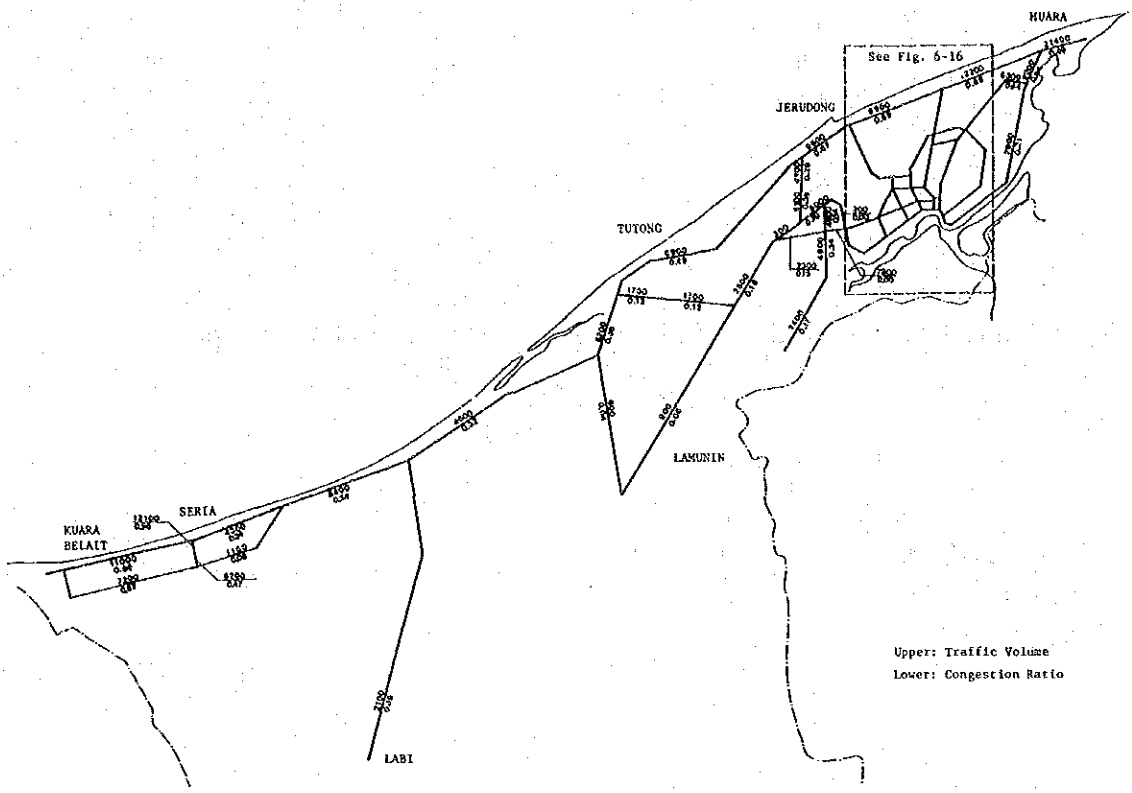


Fig. 6-15 Future Assigned Traffic (Alternative-3) – 1

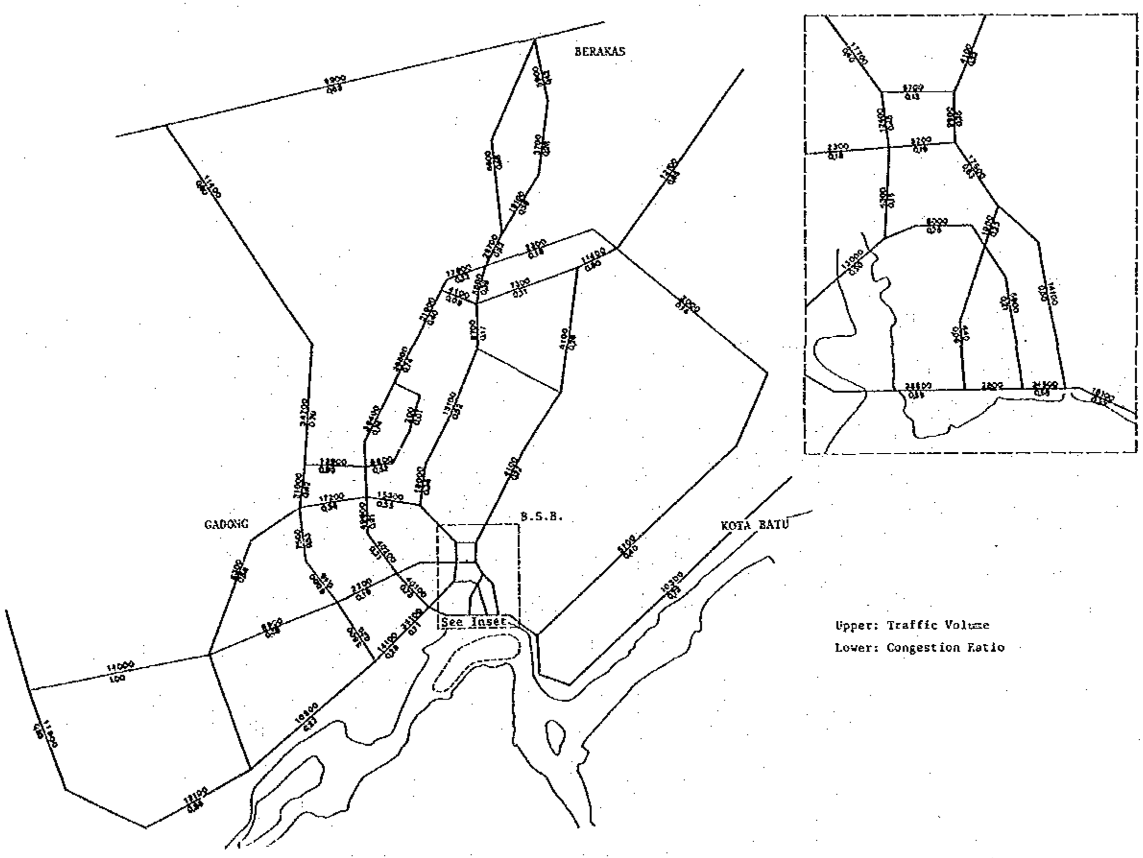


Fig. 6-16 Future Assigned Traffic (Alternative-3) – 2

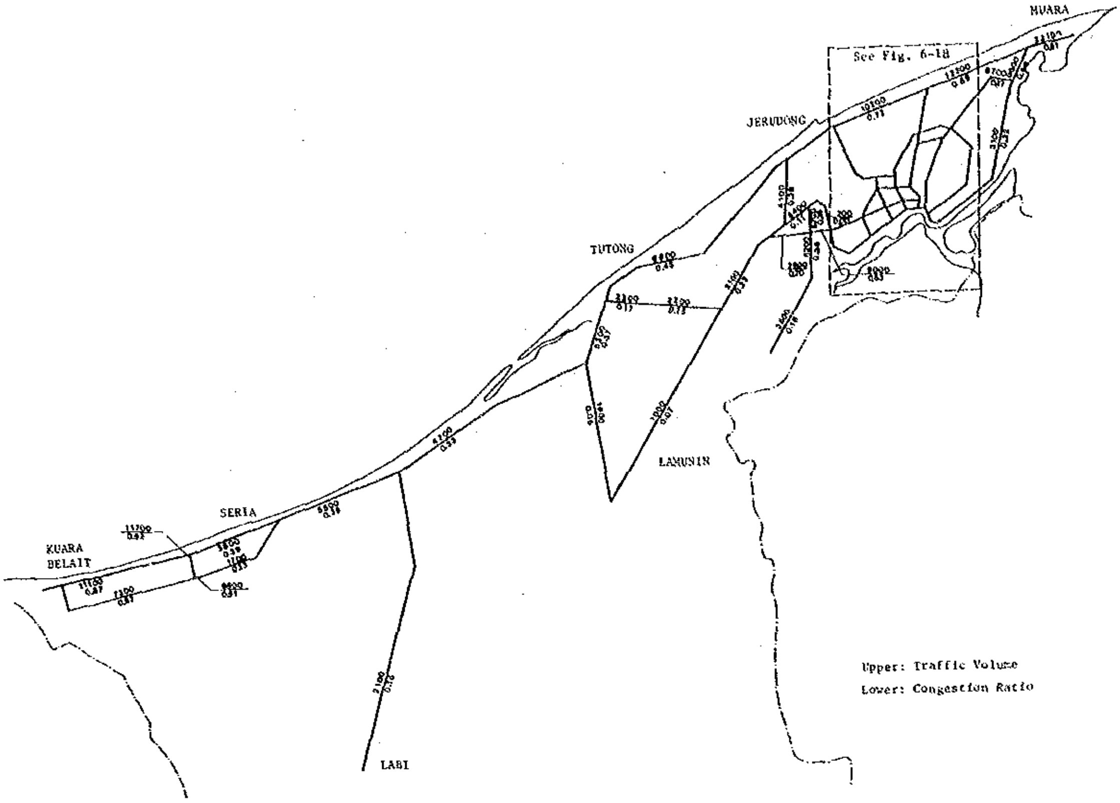


Fig. 6-17 Future Assigned Traffic (Alternative-4) – 1

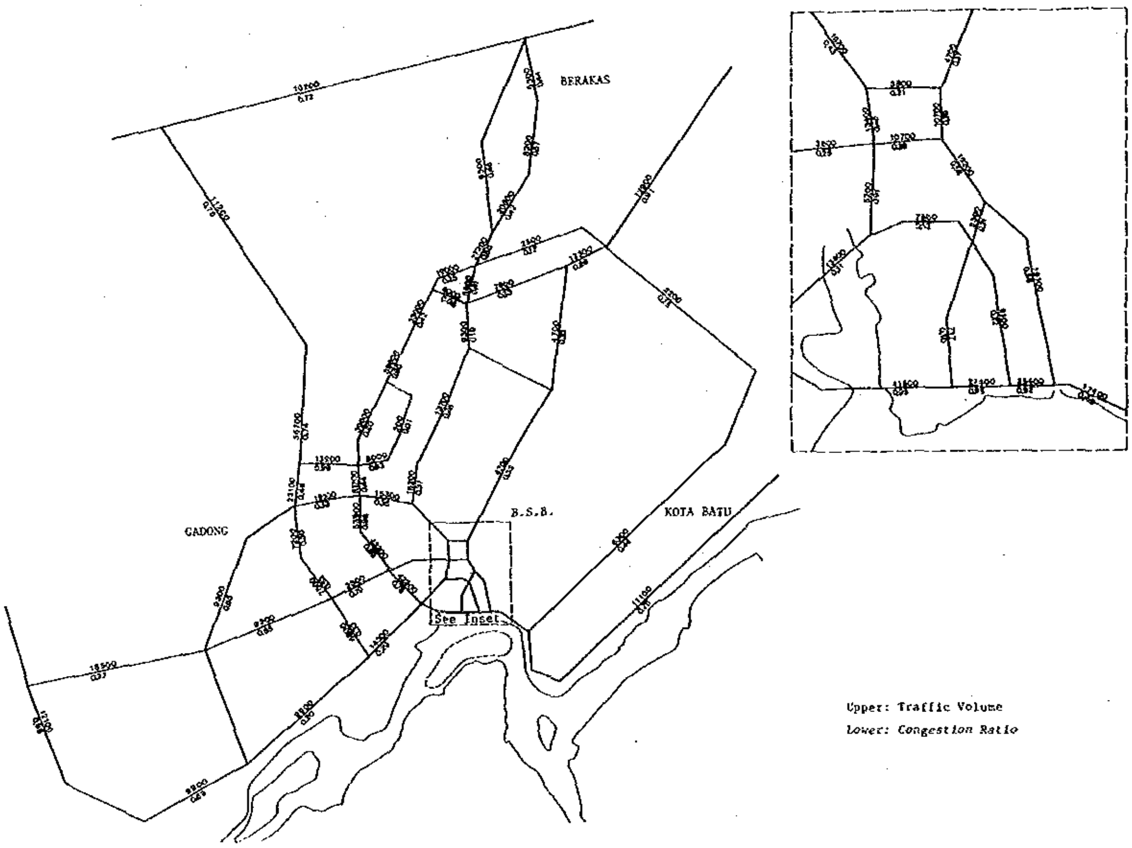
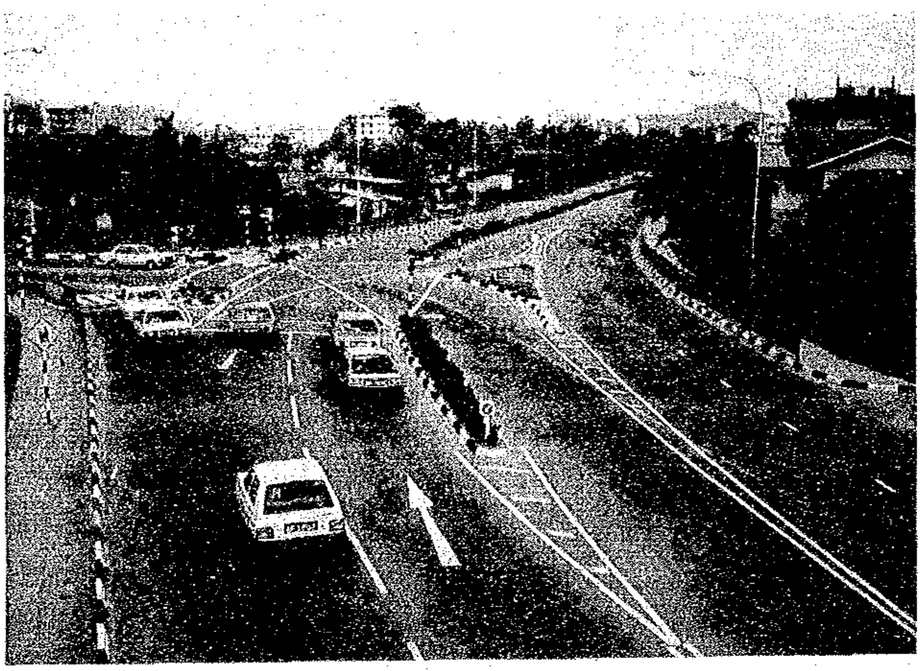


Fig. 6-18 Future Assigned Traffic (Alternative-4) – 2

CHAPTER 7

PRELIMINARY DESIGN AND COST ESTIMATION



CHAPTER 7 PRELIMINARY DESIGN AND COST ESTIMATION

7-1 Facilities for Bus Transport

7-1-1 Bus Operation

The number of bus trips per day is computed for each route when the future assigned number of bus passengers of each alternative is divided by the planned bus operating frequency of each route. Computation was made based on the assumption that bus services are provided for 15 hours a day in major cities.

The average bus occupancy at each link is also computed.

Furthermore, the total number of buses required in the case where buses are operated at the required operating frequency at the bus travelling speed at each link computed from the result of the traffic assignment is computed as shown in Table 7-1. The peak time operating frequency that is twice as much as that of the daily mean is used for the estimation of the total number of buses required.

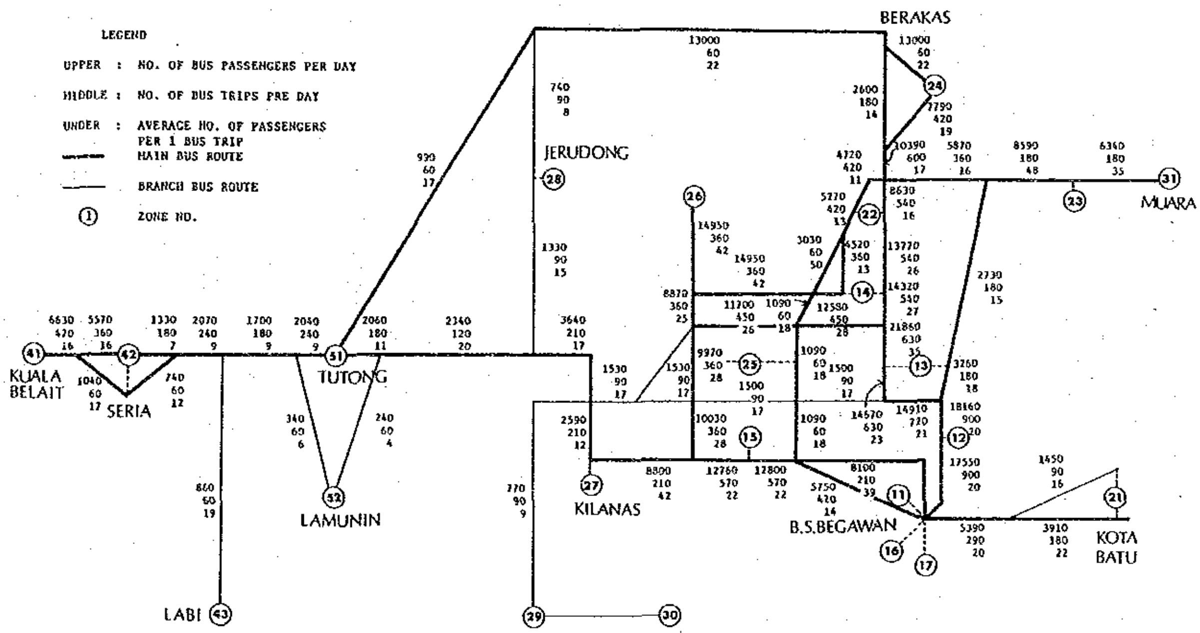


Fig. 7-1 Bus Operation Plan (Alternative 2)

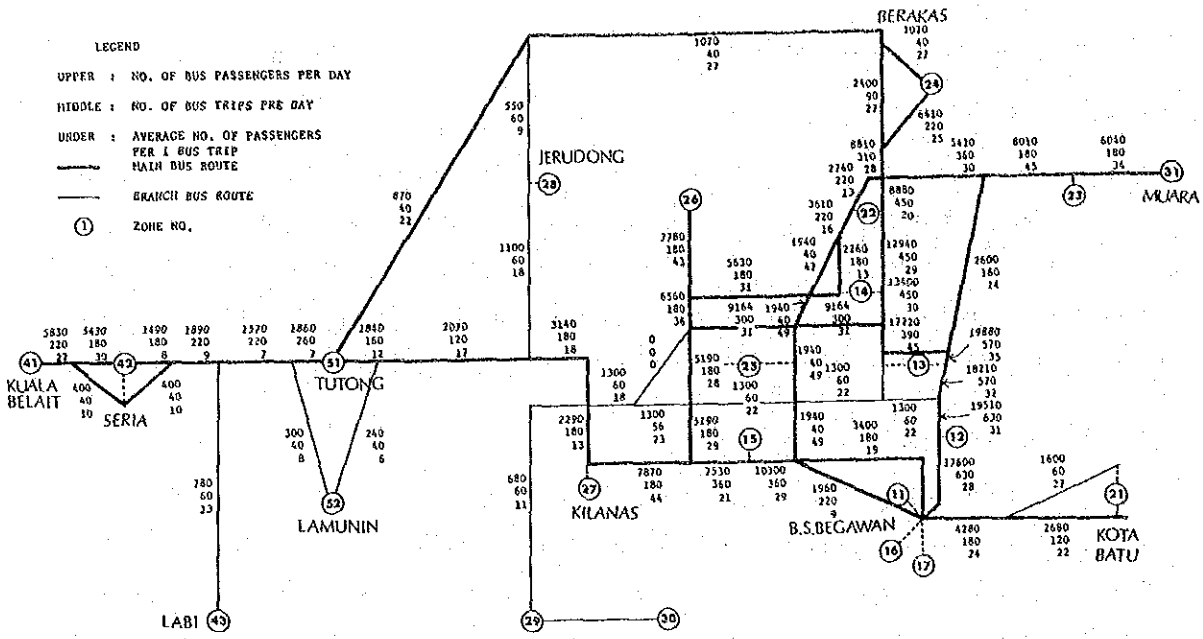


Fig. 7-2 Bus Operation Plan (Alternative 3)

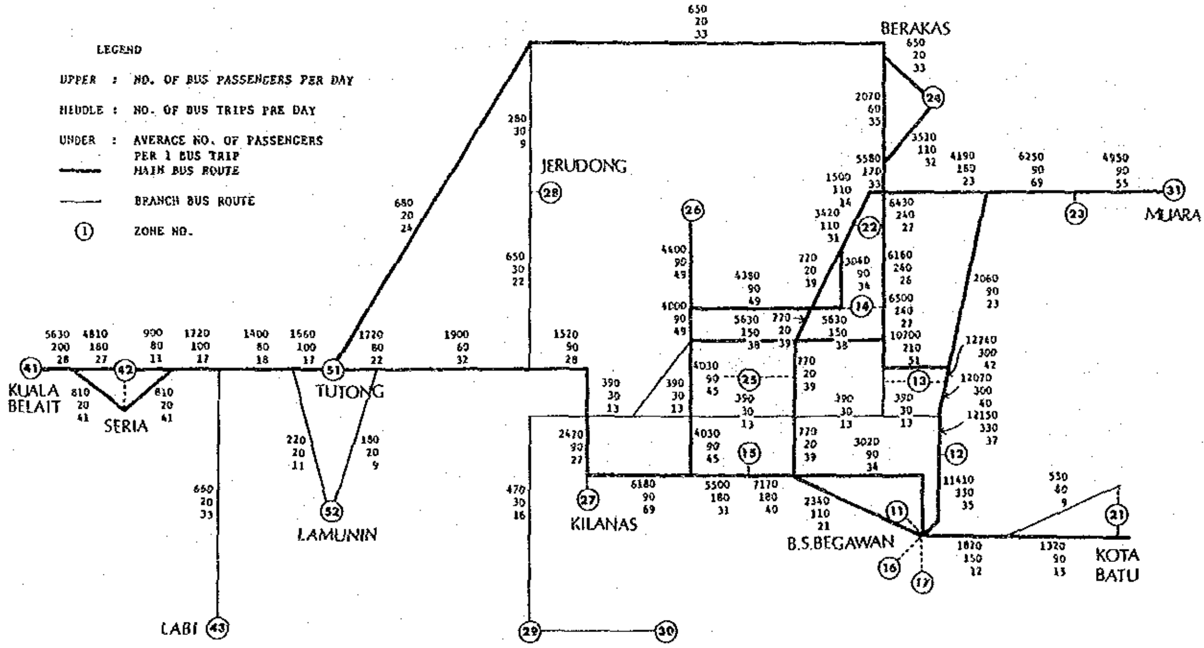


Fig. 7-3 Bus Operation Plan (Alternative 4)

Table 7-1 Comparison of Bus Routes by Alternative

Origin/Destination	Existing: No. of Bus holding	Existing: No. of Bus Trips	Existing: Average Interval of Bus Departure	Existing: Average Travel Speed	Alt.0: Proposed Travel Speed	Alt.1: Proposed Travel Speed	Alt. 2: Distance	Alt. 2: Proposed Travel Speed	Alt. 2: Average Interval of Bus Departure	Alt. 2: No. of Bus Trips	Alt. 2: Proposed No. of Bus Holding	Alt. 3: Proposed Travel Speed	Alt. 3: Average Interval of Bus Departure	Alt. 3: No. of Bus Trips	Alt. 3: No. of Bus Holding	Alt. 4: Proposed Travel Speed	Alt. 4: Average Interval of Bus Departure	Alt. 4: No. of Bus Trips	Alt. 4: No. of Bus Holding
			min	km/hr	km/hr	km/hr	km	km/hr	min			km/hr	min			km/hr	min		
(1) BSB - Gadong	1	12	85	30	6	37	64	35	20	90	6	35	15	120	7	35	30	60	6
(2) BSB - Berakas	3	32	37	25	18	47	15	30	10	180	16	40	20	90	9	40	30	60	7
(3) BSB - Muara	11	30	40	28	30	38	266	35	10	180	22	40	10	180	20	40	20	90	12
(4) BSB - Kota Batu	1	24	50	50	30	49	10	40	10	180	10	45	15	120	8	45	20	90	7
(5) Sungai- Lumapas Kebun	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(6) BSB - Jerudong	1	10	142	36	13	55	25	35	20	90	13	40	30	60	9	40	60	30	7
(7) BSB - Limau Manis	2	8	136	43	11	47	213	30	20	90	13	40	30	60	8	40	60	30	7
(8) BSB - Lamunin	4	2	-	48	20	58	-	-	-	-	-	-	-	-	-	-	-	-	-
(9) BSB - Tutong	1	-	-	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(10) BSB - Seria	20	51	26	50	24	56	92.5	50	10	120	48	50	10	120	48	50	20	60	26
(11) BSB - Hospital	-	16	80	30	5	32	-	-	-	-	-	-	-	-	-	-	-	-	-
(12) BSB - Airport	2	30	52	28	14	40	-	-	-	-	-	-	-	-	-	-	-	-	-
(13) Tutong - Tutong Camp	1	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1
(14) Kuala Belait - Seria	16	72	23	32	17	40	16.0	20	5	310	42	20	10	180	23	20	10	180	23
(15) Kuala Belait - Miri	4	12	90	-	-	-	-	-	-	4	4	-	-	-	4	-	-	-	4
(16) Seria - Labi	3	20	60	53	55	55	40.3	50	20	60	14	50	20	60	14	50	60	20	7
(17) Seria - Sungai Liang	2	-	-	60	51	51	20.3	50	20	60	9	50	30	40	7	50	60	20	6
(18) BSB - BSB							28.0	30	10	180	26	40	10	180	21	40	20	90	12
(19) BSB - Sulok							4.7	20	20	90	7	40	30	60	5	40	30	60	5
(20) Lambak - Rimba							23.1	20	5	360	59	40	10	180	18	40	20	90	11
(21) BSB - Kuala Belait							124.0	50	20	60	34	60	30	40	21	60	60	20	12
(22) Tutong - Lamunin							51.4	50	20	60	16	50	30	40	12	50	60	20	8
Total/Average	73	319	48	37	23	45	504.6		12	2,340	340		17	1530	235		27	920	160

1/ $= \left(\frac{60 \times \text{distance}}{\text{Travel speed}} + \text{Average interval}\right) \times 2 \times \frac{\text{Peak rate}}{\text{Average interval}}$ and peak rate = 2.0

7-1-2 Bus Terminal and Bus Stop

The scales of bus terminals in each alternative are as follows.

Table 7-2 Proposed Bus Terminal by Alternative

Name of Bus Terminal	No. of Existing Berth	Alt. - 2			Alt. - 3			Alt. - 4		
		No. of Routes	Extra Berth	Proposed No. of Berth	No. of Routes	Extra Berth	Proposed No. of Berth	No. of Routes	Extra Berth	Proposed No. of Berth
Kuala Belait	5	3	2	5	3	1	5	3	1	5
Seria	12	5	5	10	5	3	10	5	2	10
Tutong	-	3	2	5	3	1	5	3	1	5
B.S. Begawan	20	11	11	22	10	6	20	10	4	20
Airport	-	5	5	10	5	4	10	5	3	10
Gadong	-	4	4	10	3	3	6	3	2	5

1/ Extra Berth = No. of Bus routes operated within 10 minutes interval of departure at peak hour

The bus terminal of B.S. Begawan of Alternative 2 is of 22 berths as a result of computation, and existing 20 berths are insufficient.

However, construction of new parking building at the site of the fish market is planned by the government at the present time and it will become possible to accommodate these extra berths in this parking building.

The bus terminals to be additionally required are four places, i.e., Seria, Tutong, Airport and Gadong. Cost estimation is made using construction expenses for standard 5-berth and 10-berth bus terminals. (See Table 7-3)

The details of construction expenses for standard bus terminals are shown in Table 7-6.

a. Standard bus terminal (5 berths)

Scale

Site area	1,700 m^2
Building area	400 m^2
Bus parking space	5 buses
Taxi and car parking space	18 cars

Layout plan

It is assumed that the site will be located at a corner of a road intersection. The bus parking space and the taxi parking space are partitioned with a building in order to permit transfer without being wet even on a rainy day.

Building plan

An office, wicket room and bus boarding/unboarding shed are provided as facilities for buses; and a taxi office and taxi boarding/unboarding shed are provided as facilities for taxis. Besides, a toilet and a stand are provided. The structure is single-storied reinforced concrete building.

Construction expenses

Building	166,700 B$
Exterior	71,100 "
Land acquisition	145,000 "
Total	382,800 "

b. Standard bus terminal (10 berths)

Scale

Site area	3,000 m^2
Building area	500 m^2
Bus parking space	10 buses
Taxi and car parking space	48 cars

Layout plan

Same as that of a 5-berth bus terminal.

Building plan

Besides office, wicket room and bus boarding/unboarding shed for buses and taxi boarding/unboarding shed for taxis, a toilet are provided on the ground floor and, a waiting lounge and a stand are provided on the first floor.

The structure is two-storied reinforced concrete building.

Construction expenses

Building	250,000 B$
Exterior	126,300 "
Land acquisition	255,900 "
Total	632,200 "

Table 7-3 Bus Terminal Construction Expenses by Alterantive

(Unit: 1000B$)

		Alternative 2	Alternative 3	Alternative 4
Number of standard 10-berth bus terminals to be constructed		3	2	2
Number of standard 5-berth bus terminals to be constructed		1	2	2
Bus terminal construction unit price	10 berths	632.2 (376.3)1/	632.2 (376.3)1/	632.2 (376.3)1/
	5 berths	382.8	382.8	382.8
Construction Expenses	10 berths	1,640.7	1,008.5	1,008.5
	5 berths	382.8	765.6	765.6
	Total	2,023.5	1,774.1	1,774.1

1/ Unit price excluding land acquisition cost; for Seria bus terminal

At bus stops, bus bays will be provided in order not to obstruct general traffic, and in addition, shelters, chairs and time tables will be provided for passengers.

The standard bus stop spacing is 500 m at the town center, 1 km in the urban area, 5 km in the rural area and 10 km along the highway. In the town center, bus bays will not be provided because it is hard to secure the space of widening, and bus bays will not be provided for along branch bus routes. As the bus networks of Alternatives 2, 3 and 4 are basically the same, the construction expenses of bus stops of these alternatives are same as those shown in Table 7-4.

The details of standard bus stop construction expenses are shown in Table 7-6.

Table 7-4 Bus Stop Construction Expenses by Alternative

Alternatives 2, 3, 4

	Main Bus Route	Branch Bus Route	Standard Number of Bus Stops	Number of Required Bus Stops		
				Number of Sheds	Number of Bus Bays	
Town center	5.2 km	-	2 places/ 500 m	20	20	
Urban area	103.9 km	12.9 km	2 places/ 1 km	234	208	
Rural area	71.2 km	68.8 km	2 places/ 5 km	56	28	
Highway	74 km	-	2 places/ 10 km	14	14	
Total	254.3 km	81.7 km	-	324	270	
	Construction unit price per bus stop			10,850 B$	14,400 B$	Total
	Construction expenses			3,515,400 B$	3,888,000 B$	7,403,400 B$

7-1-3 Bus Opereration and Workshop

It is considered that 340 buses will be required in the future in Alternative 2. Bus operation offices will be provided at five places in the whole country for management of operation of these buses and also for parking of buses after termination of operation. Furthermore, workshops will be provided at two places, i.e., Gadong and Seria.

In Alternative 3 and Alternative 4, 235 buses and 160 buses are required respectively in the future. Accordingly, four bus operation offices and one workshop will be provided in the whole country.

The expenses for construction of bus operation offices and workshops are estimated based on standard designs, because conditions such as location, geology and ground have not yet been finalized.

a) Typical bus operation office

Scale

Site area	12,000 m^2
Building's total floor space	1,000 m^2
Clerk	30 persons
Driver	120 persons
Bus	50 buses

Layout plan

As each bus operation office is provided mainly for management of operation of buses in its territory, an office is provided near the entrance of the site, and private car parking area, car/bus washing area, gas filling station and bus parking area are located before the office.

Building plan

Minor servicing yard, driver's locker room, night watchman's room, shower room, operation office, toilet, etc., are provided on the ground floor; and office, cafeteria, toilet, etc. are provided on the first floor.

The structure is two-stories reinforced concrete building.

Construction expenses

Building	1,000,000 B$
Exterior	437,500 B$
Land acquisition	240,000 B$
Total	1,677,500 B$

Details are shown in Table 7-6.

b) Typical workshop

The scale of a typical workshop is computed with the following equation.

$$S_N = \frac{N}{(\frac{n}{n_0})}$$

S_N ..... Number of required stools

N ..... Number of buses to be serviced per month

n ..... Number of working days per month

n_0 ..... Number of days of stool occupation

Stools for major servicing

If it is assumed that the number of buses assigned to the workshop is 235, major servicing is of 24 month period and number of working months per year is 10 months;

$$n = 235 \times \frac{12}{24} \times \frac{1}{10} \fallingdotseq 12$$

It is assumed that the number of working days per month is 24 days and number of days of stool occupation is 4 days.

From the above, the number of stools for major servicing is;

$$S_N = \frac{12}{(\frac{24}{4})} = 2 \text{ stool}$$

Stools for periodic servicing

If it is assumed that the number of buses assigned to the workshop is 235, servicing is made once every three months in 24 month period and number of working months per year is 10 months;

$$N = 235 \times \frac{(\frac{24}{3} - 1)}{2} \times \frac{1}{10} = 82$$

It is assumed that the number of working days per month is 24 days and the number of days of stool occupation is one day.

$$S_N = \frac{82}{(\frac{24}{1})} = 3 \text{ stools}$$

Layout plan

Flow lines of repair and servicing functions were established, the paths on the ground and parking space are determined and planning is made so that flow of buses in the workshop is smooth.

Building plan

Walls were limited to what are minimum required for the required function, in order to provide an open field of vision in the workshop.

The parts room is provided on the ground floor, and the offices are provided on the ground floor and mezzanine.

The structure is steel frame building.

Construction expenses

Building	1,000,000 B$
Exterior	133,300 B$
Servicing equipment	500,000 B$
Land acquisition	100,000 B$
Total	1,733,300 B$

Details are shown in Table 7-6.

c) Construction cost by alternative

The construction cost by alternative is as shown in Table 7-5 from typical construction costs, number of bus operation offices and number of workshops.

Table 7-5 Bus Operation Office and Workshop Construction Cost by Alternative

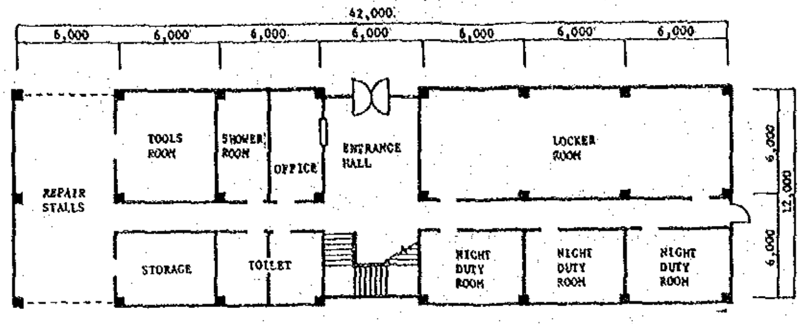
(Unit : 1000 B$)

Item	Alt-2	Alt-3	Alt-4
No. of Operation Office	5	4	4
No. of Workshop	2	1	1
Typical Construction Cost			
Operation Office	1,677.5	1,677.5	1,677.5
Workshpp	1,733.3	1,733.3	1,733.3
Construction Cost			
Operation Office	8,387.5	6,710.0	6,710.0
Workshop	3,466.6	1,733.3	1,733.3
Total	11,854.1	8,443.3	8,443.3

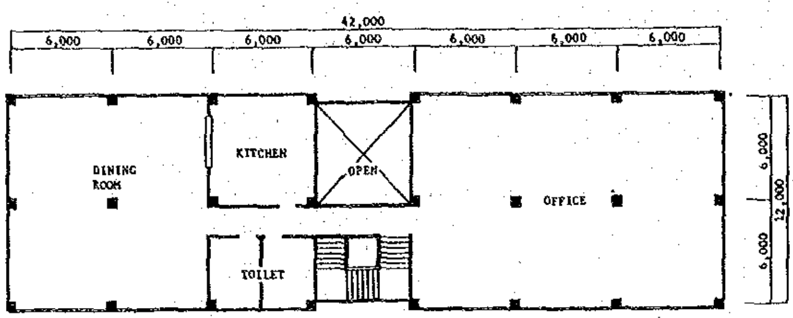
Table 7-6 Detail of the Typical Construction Cost

Item	Construction Cost		
Bus Operation Office	Land acquisition	$12{,}000\ m^2 \times 20\ \$/m^2 =$	240,000 $
	Construction cost		
	Temporary work	70,000$	
	Civil engineering work	25,000	
	Body work	345,000	
	Interior work	176,000	
	Facing work	155,000	
	Equipment work	229,000	
	Exterior work	437,500	
		1,435,500	
	Total		1,675,500
Workshop	Land acquisition	$5{,}000\ m^2 \times 20\ \$/m^2 =$	100,000 $
	Construction cost		
	Temporary work	63,000	
	Civil engineering work	37,000	
	Body work	400,000	
	Interior work	273,000	
	Facing work	137,000	
	Equipment work	90,000	
	Exterior work	133,330	
	Bus servicing equipment	5,000,000 1/	
	Total		1,733,330
Bus Terminal (10 Berths)	Land acquisition	3,000 m x 85.3 $/m =	255,900 $
	Construction cost		376,250
	Temporary work	15,750	
	Civil engineering work	9,250	
	Body work	100,000	
	Interior work	68,250	
	Facing work	34,250	
	Equipment work	22,500	
	Exterior work	126,250	
	Total		632,150 $

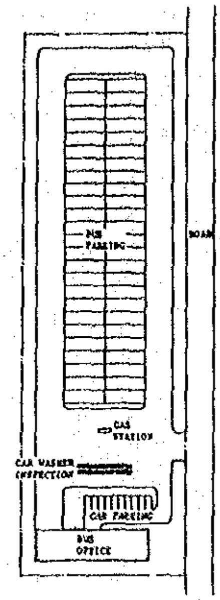
Item		Construction Cost	
Bus Terminal (5 berths)	Land acquisition	1,700 m x 85.3 $/m =	145,010
	Construction cost		237,750
	Temporary work	10,500	
	Civil engineering work	6,180	
	Body work	66,680	
	Interior work	45,500	
	Facing work	22,840	
	Equipment work	15,000	
	Exterior work	71,050	
	Total		382,760
Bus Stop	Bus stop shed	10,850 $	
	Paving work	14,400 $	
	Lighting work	12,500 $	
	Total	37,750 $	
1/	Bus servicing equipment		
	Inspection equipment	6,320 $	
	Lift/jack equipment	12,550 $	
	Cleaning equipment	15,500 $	
	Oil supply equipment	7,400 $	
	Equipment for tires and brakes	68,200 $	
	Air compressors and accessories	4,730 $	
	Body servicing equipment	8,750 $	
	Engine tuneup equipment	1,850 $	
	Engine servicing equipment	336,280 $	
	Pneumatic tools	4,920 $	
	Hand tools	28,300 $	
	General measuring instruments and tools	5,200 $	
	Total	5,000,000 $	



GF PLAN

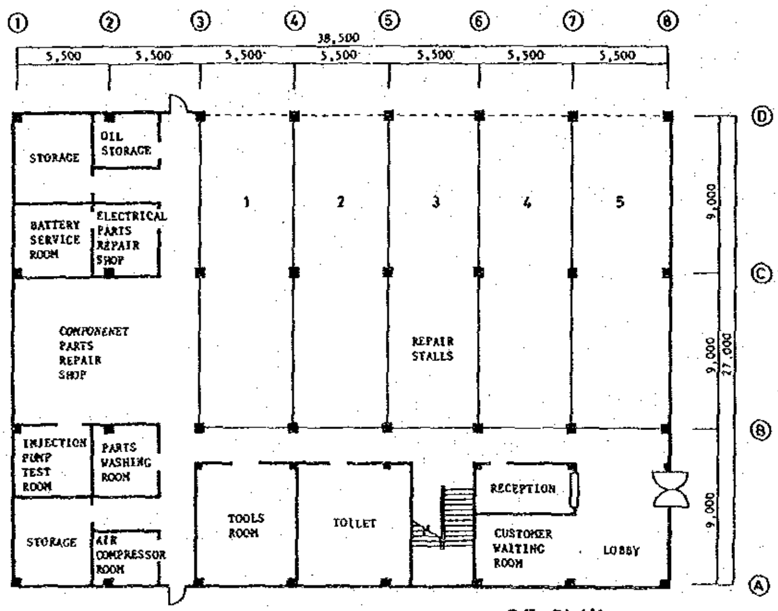


1F PLAN



PLOT PLAN

BUS OFFICE



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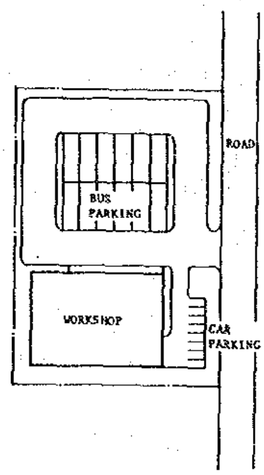

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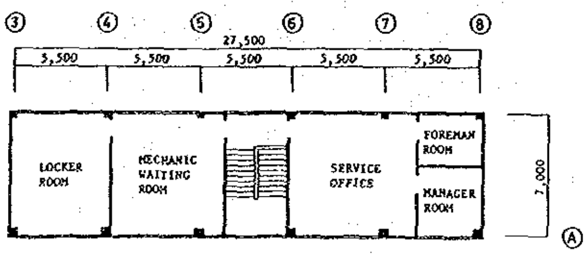
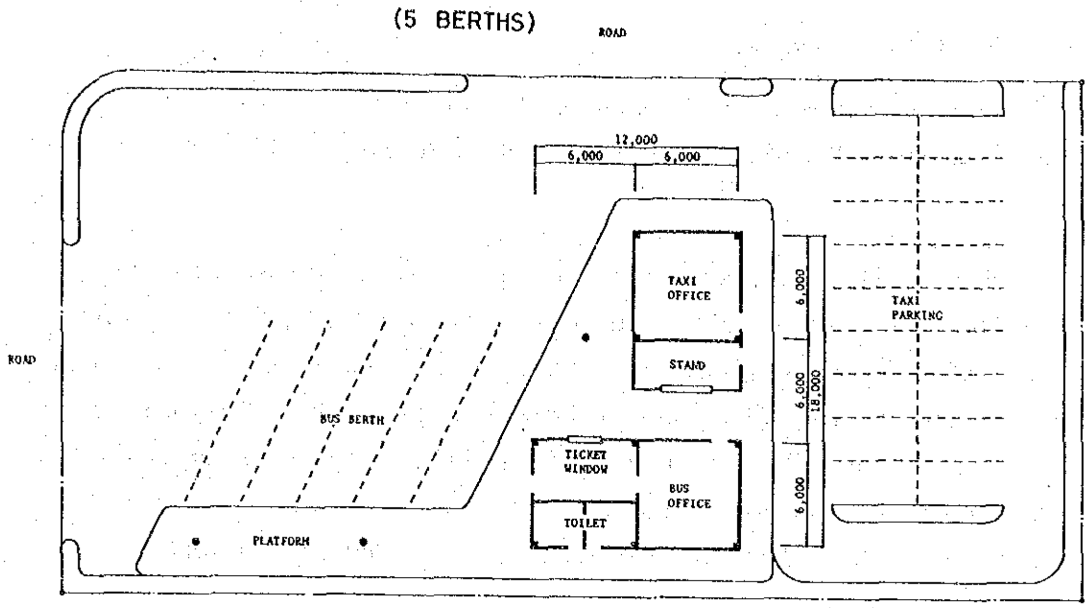


1F PLAN

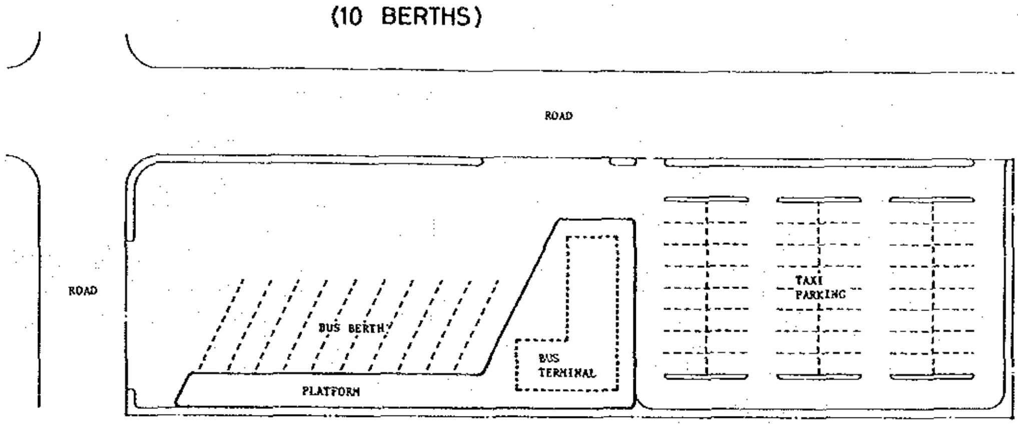
WORKSHOP

BUS TERMINAL
(5 BERTHS)



PLOT PLAN

BUS TERMINAL
(10 BERTHS)



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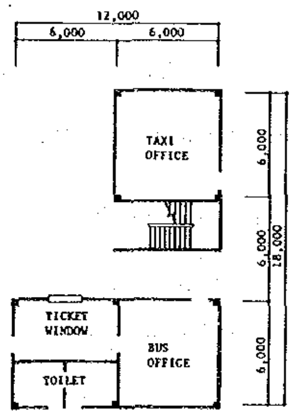

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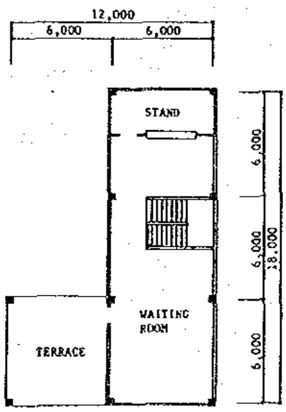


1F PLAN

7-2 Road and Intersection

7-2-1 Preliminary Design for Road

Preliminary design has been made for each one of roads to be newly constructed and road to be expanded proposed in Alternative 1-4.

For execution of preliminary design, topographical maps of S = 1 : 12,500 are available for around B.S.B. and topographical maps of S = 1 : 50,000 are available for other areas, measurements are made on these maps and then plan designing and vertical designing have been done. The bill of quantity of preliminary designs is computed to the cost estimation items to be described later. Preliminary designs are contained in the materials volume (separate volume).

The geometrical design criteria used for preliminary designs are as follows.

a. Geometric design criteria

Table 7-7 Geometric Design Criteria

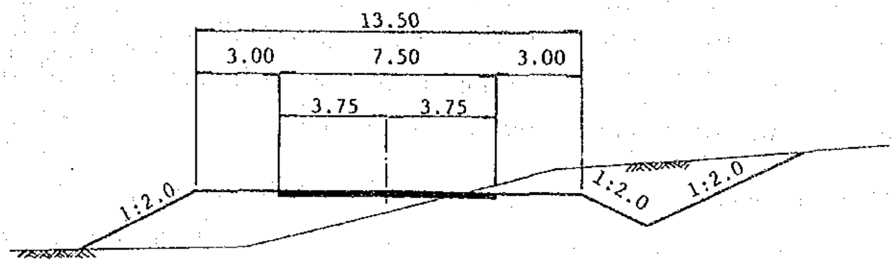
Item	Unit	Road Type	
		Two Lane Arterial	Four Lane Arterial
Design speed	km/hour	80	100
Minimum radius	m	280	460
Maximum gradient	%	5	4
Maximum superelevation	%	10	10
Vertical clearance over roadways	m	4.8	4.8

*1 Setup of design criteria is based on B.S. Standard, Road note No. 29 - 31.

*2 The vertical gradient of the grade separated intersection of four lane arterial roads is maximum 5% with their extensions taken into account.

b. Typical cross section

Two Lane Arterial



Four Lane Arterial

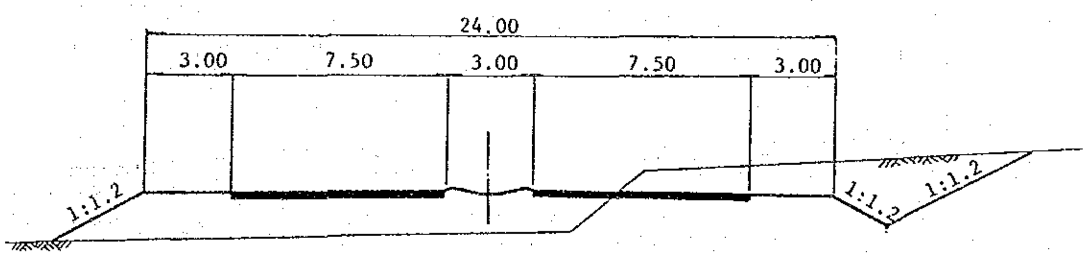


Fig. 7-4 Typical Cross Section

7-2-2 Preliminary Design for Intersection

For at-grade intersections, cost estimation have been done as a typical intersections with general required facilities, that is, signals, marking, guide signs and lighting as standard facilities.

The places of grade separated intersections are set based on the result of the future traffic assignment. Accordingly, a preliminary design has been made for a typical four-lane intersection and the bill of quantities has been estimated for one place.

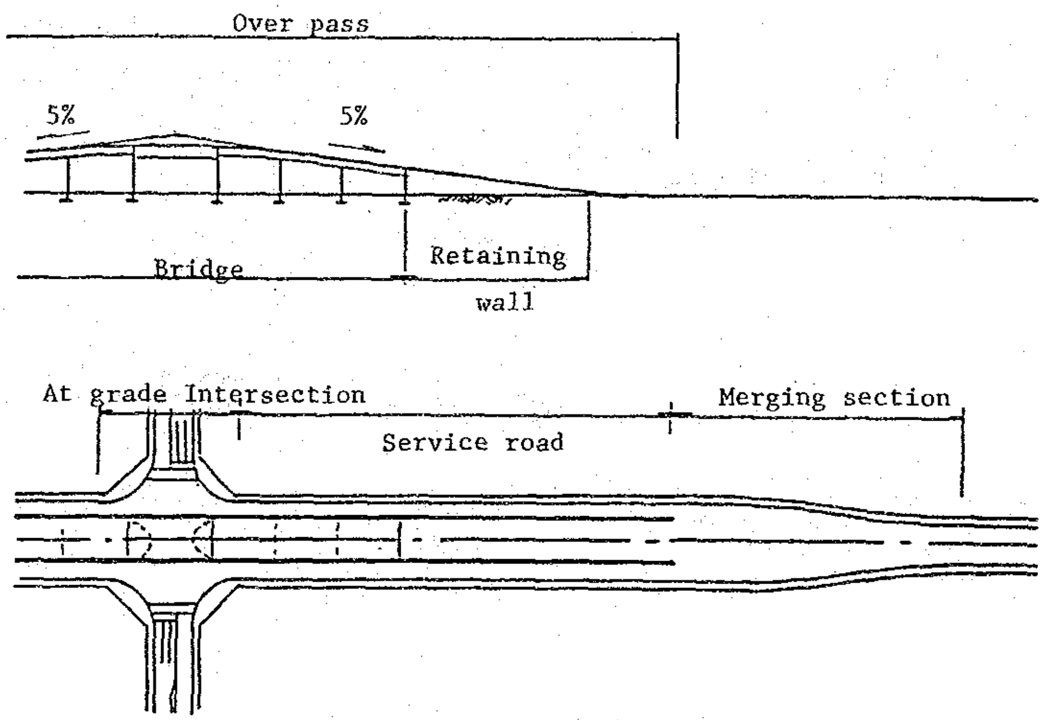


Fig. 7-5 Grade Separated Intersection

7-2-3 Unit Construction Cost and Unit Land Acquisition Cost

The unit construction cost and unit land acquisition cost are computed on the following items. The unit construction cost is composed of unit prices of individual materials, equipment and labor. These figures used in the estimation are sufficiently reflected the circumstances and conditions of construction in Brunei. The computed unit prices are shown in Table 7-7.

Land Clearing

The unit costs for land clearing are computed as classified into mountainous/hilly areas and swampy areas (soft grounds). Land clearing for soft grounds included sand map of 50 cm thick.

Earthworks

The costs for earthworks are computed on items of cutting, filling and transport. In the case of that the earth volume is balanced between cutting and filling, the cost is estimated as in cutting and filling. If transport of earth from other places or disposal of earth to other places occurs, the cost is estimated as in cut/fill and transport.

Pavement

The pavement unit prices are computed based on the following pavement composition.

Surface course	Hot mix asphalt	t = 50 mm
Base course	Asphalt stabilization	t = 100 mm
Upper sub-base	Cement stabilization	t = 150 mm
Lower sub-base	Crushed Stone	t = 150 mm

Drainage structures

Drainage structures include side ditches, box culverts, pipe culverts and their inlets/outlets. For a 4-lane road, drainage work for the median island is included besides the above.

Turfing of road shoulder

Turfing is applied to soft shoulders.

Slope protection

It is assumed that slope protection is made by spraying seeds to both cut slopes and filled slopes.

Structures

Computation is made with bridges over rivers and bridges at grade separation classified into single span bridges of span up to 30 m and multi-span bridges of span 40 - 60 m. Computation of retaining walls is made for categories of height 6.0 m, 3.5 m and 1.5 m.

Highway appurtenances

Highway appurtenances for 2-lane roads include guard rails, marking and guide signs. Highway appurtenances for 4-lane roads include traffic signals at intersections and road lighting in addition to the above.

Utilities

Costs required for removal of public utilities facilities, i.e., electric power, telephone, waterworks and sewage, relevant to road construction are estimated.

Miscellaneous

Costs required for tentative provision of roads and traffic detouring measures accompanying road construction are estimated.

Land acquisition

This is the cost for acquisition of the rights to use the land for roads and for accompanying compensation. Land acquisition cost is set for three categories, i.e., urban housing area, regional housing area and regional field. The width of the land for newly constructed roads is 40 m for a 2-lane road and 60 m for a 4-lane road.

Table 7-8 Unit Construction Costs

As of 1984

Item No.		Items	Unit	Unit Cost	Remarks
				B$	
01	101	Land Clearing	sq m	1.20	Common
	102			8.20	Swampy
02		Earthworks			
	101	Cutting	cu m	6.30	
	102	Filling	cu m	6.30	
	103	Cut/Fill & Transport	cu m	14.70	
03	101	Pavement	sq m	85.30	
04	101	Drainage Structures	km	200,000.00	0 2L. Const.
	102			300,000.00	1 4L. Const.
05	001	Turfing of Road Shoulder	sq m	10.00	
06		Slope Protection			
	101	Cutting Slope	sq m	4.70	
	102	Filling Slope	sq m	4.70	
07		Structures			
	101	Long Span Bridges	sq m	1,490.00	
	102	Short Span Bridges	sq m	1,040.00	
	103	Retaining Walls H=6.0M	m	4,470.00	
	104	Retaining Walls H=3.5M	m	2,730.00	
	105	Retaining Walls H=1.5M	m	350.00	
08	001	Highway Appurtenances	km	76,980.00	
				185,000.00	
09	001	Utilities	km	370,000.00	
10		Miscellaneouses	Unit	-	( ) 10% of aboves
				Total	
11		Design and Supervision	Unit	-	10% of Sub Total
12		Contigencies	Unit	-	10% of Sub Total
13		Land Acquisition			
	101	Urban Housing Area	sq m	320.00	
	102	Regional Housing Area	sq m	20.00	
	103	Regional Field	sq m	8.00	

7-2-4 Construction Cost by Alternatives

a) Road construction cost

Alternative-wise road construction costs computed by applying the unit cost to the work quantity obtained as a result of preliminary design as follows.

As the result of the traffic forecase in 1995, the link between JLN. Berakas to JLN. Muara (Major arterial road phase II) by each Alternative was proposed to be 2 lanes.

Therefore, it was applied to the cost estimation and the economic evaluation that the cost reduction of 2 lanes was allocated to the 4-lane link initially proposed by the government.

Furthermore, an additional economic evaluation to the under-construction 4-lane link is made after a series of economic analysis.

Link Name	Length (km)	Number of Lanes
1. MUARA/JERUDONG COASTAL ROAD	23.0	E-2
5. TUNGKU LINK ROAD	8.6	E-2
7. MAJOR ARTERIAL ROAD II	2.4	Width reduced -2
9. BERAKAS LINK	3.9	E-2
16. JLN. TUTONG (ISTANA-JLN. JERUDONG)	10.0	E-2
22. MAJOR ARTERIAL ROAD III	1.3	N-4
23. JLN. RESIDENCY	0.7	E-2
24. TUNGKU/GADONG LINK	1.2	N-4
27. TUNGKU/AIRPORT RAMA LINK	1.5	N-2
28. JLN. HAJI BASIR EXT. LINK	0.6	N-4
29 JLN. GADONG (OUTSIDE OF RING ROAD)	1.4	E-2
30. JLN. BERAKAS (SURUSUP LINK)	0.4	E-2
31. JLN. GADONG (Kpg.Beribi - J.TUTONG)	3.8	E-2

exp.
E: Expanded Lane
N: Newly constructed

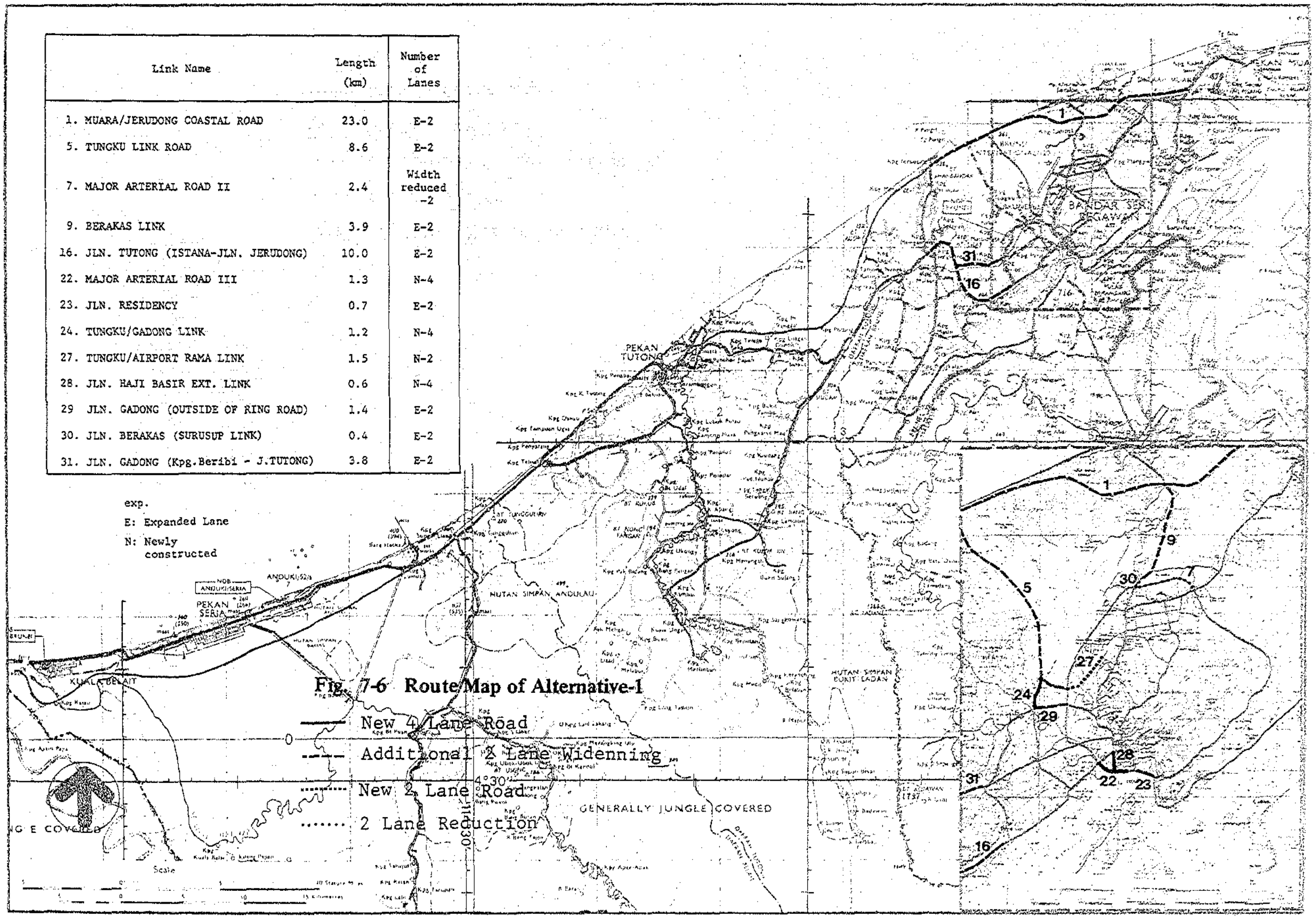


Fig. 7-6 Route Map of Alternative-1

Link Name	Length (km)	Number of Lanes
5. TUNGKU LINK ROAD	3.5	E-2
7. MAJOR ARTERIAL ROAD II	2.4	Width reduced -2
9. BERAKAS LINK	1.4	E-2
17. KILANAS LINK	1.7	N-2
19. BURONG PINGAL LINK	1.3	N-2
21. JLN. MULAUT/JLN. TUTONG LINK	1.8	N-2
22 MAJOR ARTERIAL ROAD III	1.3	N-4
23. JLN. RESIDENCY	0.7	E-2
24. TUNGKU/GADONG LINK	1.2	N-4
27. TUNGKU/AIRPORT RAMA LINK	1.5	N-2
29 JLN. GADONG (OUTSIDE OF RING ROAD)	1.4	E-2
30 JLN. BERAKAS (SURUSUP LINK)	0.4	E-2

exp.

E: Expanded lane

N: Newly constructed

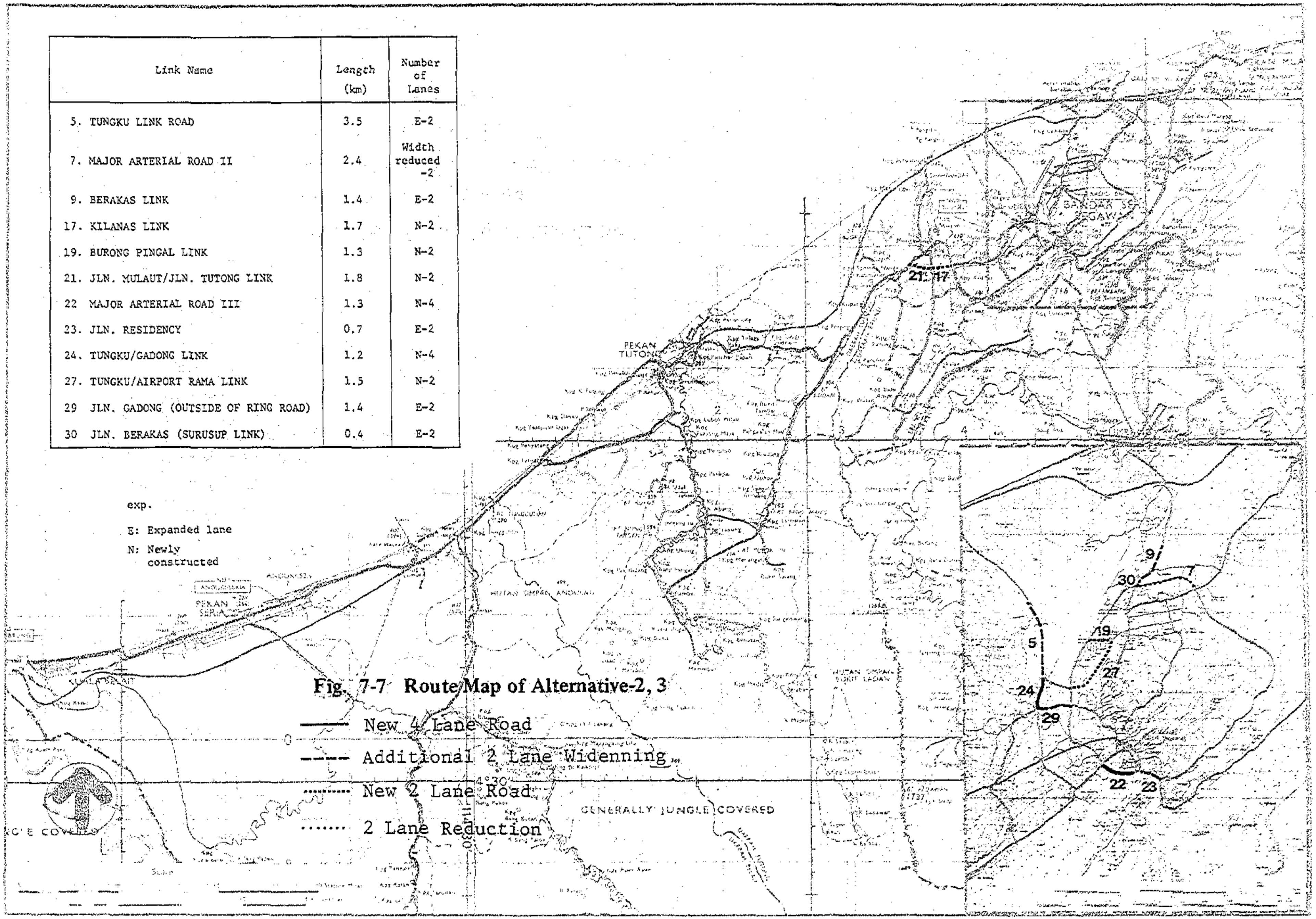


Fig. 7-7 Route Map of Alternative-2, 3

Link Name	Length (km)	Number of Lanes
5. TUNGKU LINK ROAD	3.5	E-2
7. MAJOR ARTERIAL ROAD II	2.4	Width reduced -2
9. BERAKAS LINK	1.4	E-2
17. KILANAS LINK	1.7	N-2
19. BURONG PINGAI LINK	1.3	N-2
21. JLN. MULAUT/JLN. TUTONG LINK	1.8	N-2
22. MAJOR ARTERIAL ROAD III	1.3	N-2
23. JLN. RESIDENCY	0.7	E-2
24. TUNGKU/GADONG LINK	1.2	N-4
27. TUNGKU/AIRPORT RAMA LINK	1.5	N-2
29. JLN. GADONG (OUTSIDE OF RING ROAD)	1.4	E-2
30 JLN. BERAKAS (SURUSUP LINK)	0.4	E-2
31. JLN. GADONG (Kpg.Beribi - J.TUTONG)	3.8	E-2

exp.
E: Expanded Lane
N: Newly constructed

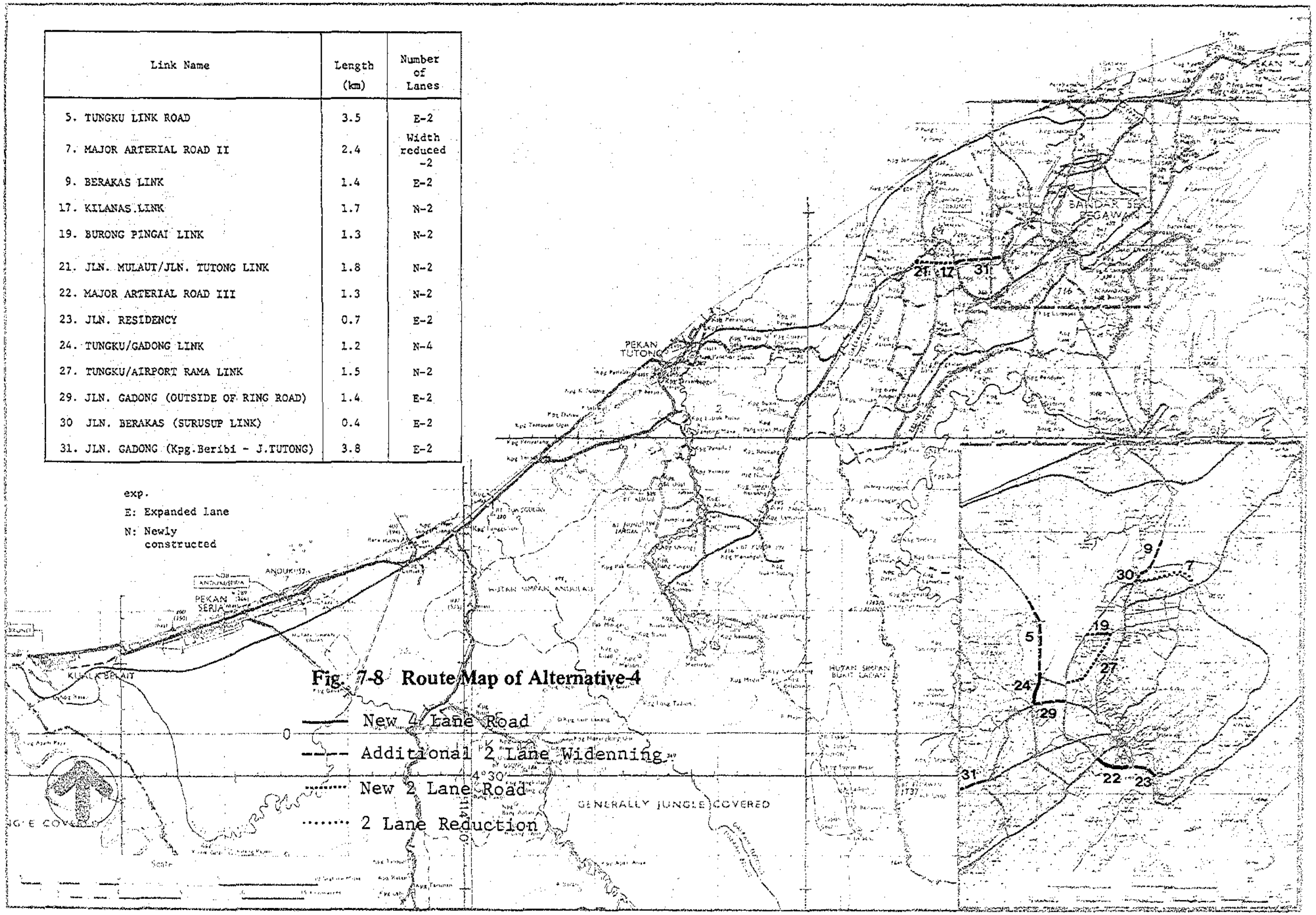


Fig. 7-8 Route Map of Alternative-4

Table 7-9 Road Construction Cost

X10⁶B$

Alternative	No. of Lanes and Extension		Total Cost	Breakdown	
Alternative 1	Expanded 2 lanes	51.8km	318.5 (310.2) 2/	Construction cost	200.1 (193.2)
	Newly constructed 2 lanes	1.5km		Engineering cost inclu-ding design	9.1 (8.8)
	Newly constructed 4 lanes	3.1km		Construction supervision cost	9.1 (8.8)
	Width reduced 2 lanes	(-2.4km) 1/		Land Acquisition cost	100.2 (99.4)
	Total	56.4km(54.0)			
Alternatives 2, 3	Expanded 2 lanes	7.4km	103.2 (94.9) 2/	Construction cost	62.7 (55.8)
	Newly constructed 2 lanes	6.3km		Engineering cost including design	2.9 (2.53)
	Newly constructed 4 lanes	2.5km		Construction supervision cost	2.8 (2.53)
	Width reduced 2 lanes	(-2.4km) 1/		Land acquisition cost	34.8 (34.0)
	Total	16.2km(13.8)			
Alternative 4	Expanded 2 lanes	11.2km	116.1 (107.8) 2/	Construction cost	71.7 (64.8)
	Newly constructed 2 lanes	6.3km		Engineering cost including design	3.3 (3.0)
	Newly constructed 4 lanes	2.5km		Construction supervision cost	3.3 (2.9)
	Width reduced 2 lanes	(-2.4km) 1/		Land acquisition cost	37.8
	Total	20.0km(17.6)			

1/ Width reduced 2 lanes means the section between JLN Berakas and JLN Muara of the 4-lane ring road - Major arterial road Phase II - currently under construction by the govern- ment, which is considered to be sufficient with two lanes from the viewpoint of the traffic demand in 1995. Computation is made as reduction of road cost with two lanes.

2/ Figures in ( ) are what take into account reduced cost of Major arterial road II to 2-lane road.

b) Grade separation

It is judged that grade separation is required from the results of the future traffic demand at intersections of each alternative.

The criteria for judgement of grade separation are set as follows from the traffic capacity per hour and anticipated peak factor (12%) of at-grade junctions. When it is assumed that each entry point of an at-grade junction is composed of one lane for forward travelling, one lane for mixture of forward and left turn and one lane only for right turn. When correction factor such as mixture of large size vehicles and service level are taken into account, a capacity of about 3,900 vehicles per green hour can be anticipated at maximum per entry point. As the peak factor is 12%, the maximum value of the traffic capacity per day per entry point is about 30,000 vehicles.

When time splitting at an at-grade junction is taken into accout, the relation of the traffic capacity between entry points which make intersection to each other is as follows.

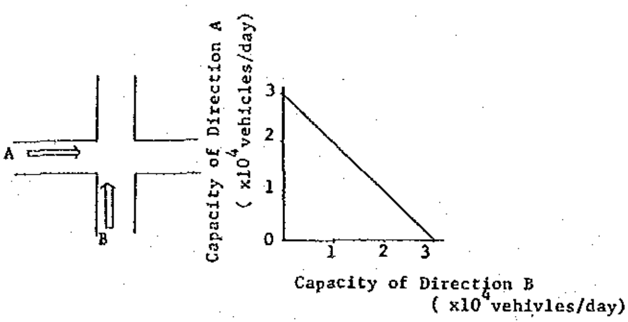


Fig. 7-9 Road Capacity at the Intersection

Based on this capacity standard, capacity examination for at-grade junctions are made using a double direction ratio, 60% to the estimated future traffic volume.

As a result of examination, it is judged that, besides three grade separations currently under construction by the government, grade separation is required at two places (Alternative 1) or at one place (Alternatives 2, 3, 4). The places where grade separation is required are illustrated below.

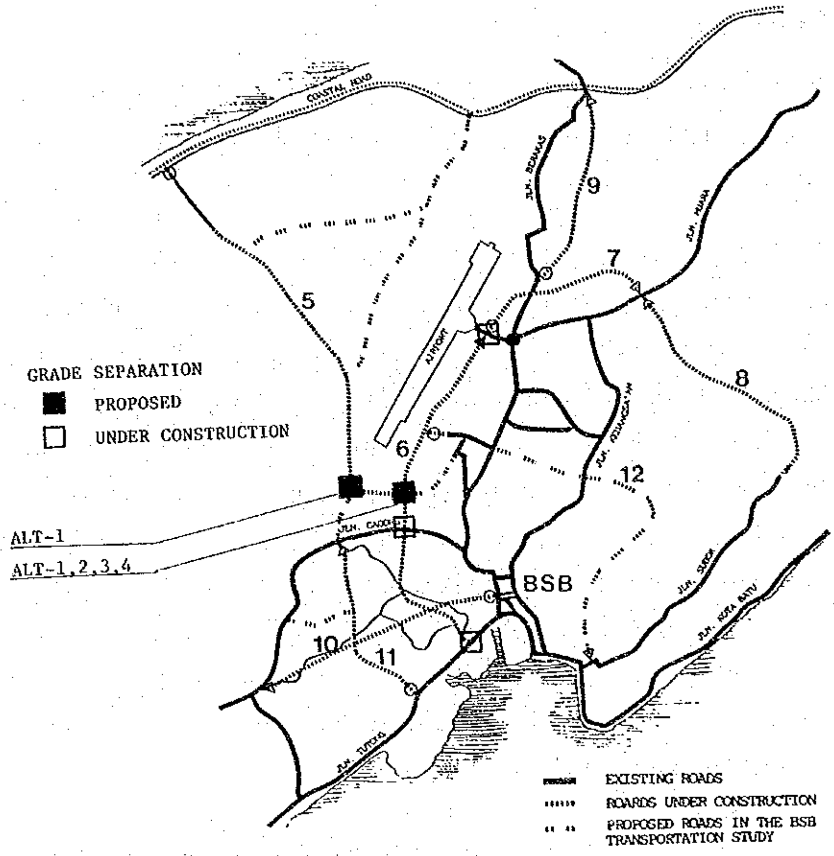


Fig. 7-10 Location Map of Grade Separation (Alternative 1)

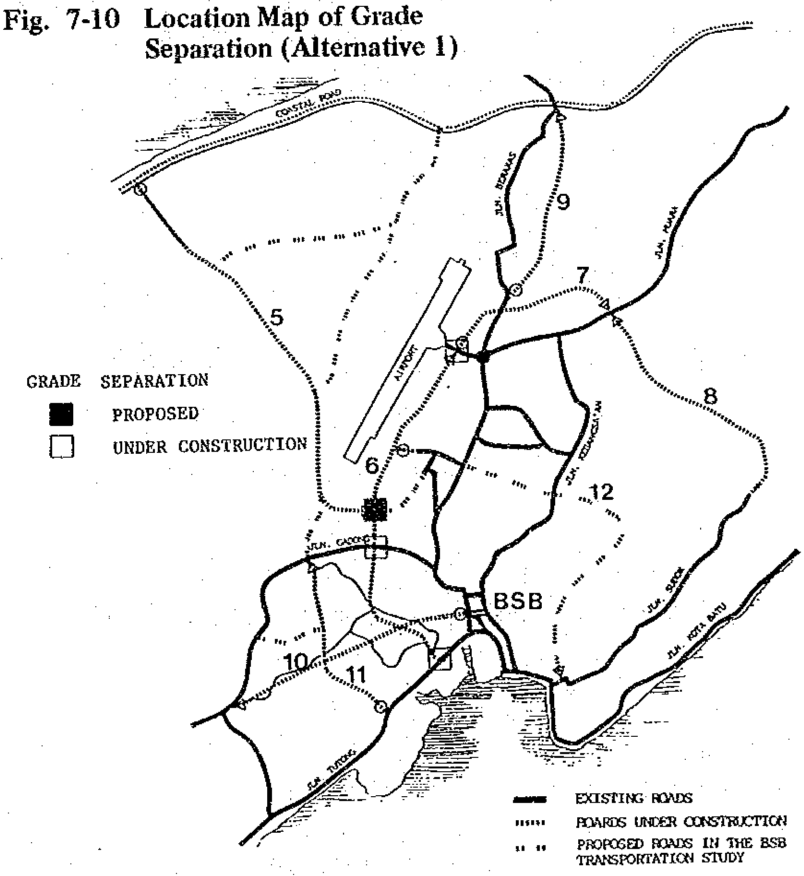


Fig. 7-11 Location Map of Grade Separation (Alternative 2, 3, 4)

Table 7-10 Grade Separation Construction Cost

x10^{6}B$

Alter-native	No. of Places	Total Cost	Breakdown	
Alter-native 1	2 places	28.8	Construction cost	18.4
			Engineering cost including design	0.84
			Construction supervision cost	0.84
			Land acquisition cost	8.7
Alter-natives 2, 3, 4	1 place	14.4	Construction cost	9.2
			Engineering cost including design	0.4
			Construction supervision cost	0.4
			Land acquisition cost	4.4

7-3 Parking

7-3-1 Basic Policy

It is necessary to provide parking areas which correspond to each alternative.

As for the provision of public parking areas it is considered that problems will occur mainly in the town center from the standpoints of acquisiton of land, degree of concentration of use, etc. Therefore, the present problems in the town center are examined in the following. The provision of parking areas at the town center is also effective from the viewpoint of materialization of smooth bus transport through elimination of illegal parking and correspondence to increase of motor traffic. However, excessive provision of parking areas will generate unnecessary entry of cars to the town center, and therefore, it is not desirable for the development of the traffic condition at town center.

Based on the viewpoints described above, setup is made to provide a service level of parking areas to each alternative that is equal to the present situation, and the required parking capacity is examined.

7-3-2 Present Service Level

Public parking areas at the town center are located at 25 places with a total capacity of 2,250 cars at the present time, and many of these parking areas are almost full in the day time. The generated and attracted traffic volume in the town center is corresponded 43,675 cars at present. Some private parking areas are available at present but the service level of public parking areas to the generated and attracted traffic volume is 5.2%.

7-3-3 Future Parking Demand

a) Demand caused by increase of traffic volume

The traffic generation and attraction of the midtown zone of each alternative is as follows.

Table 7-11 Traffic Generation and Attraction of Midtown Zone

		Traffic Generation and Attraction (cars/day)	Increase Rate (%)
Present		43,675	100
Alternative	0	48,076	110
"	1	49,788	114
"	2	39,939	91
"	3	41,820	96
"	4	46,069	105

The increase rate of 14% in Alternative 1 is the largest and the increase rates are not very large in the other alternatives. In the case of Alternative 1, the required parking capacity to cover this increase is 2,250 x 0.14 = 315 (cars).

b) Reduction of capacity caused by a prohibition of parking for smoothening bus transport

Prohibition of parking on the road obstructed by double parking in the town center can be considered as a means for smoothening bus transport. If parking along two streets, i.e., Jln. Sultan and Jln. McArthur, is prohibited for this purpose, the parking area capacity will be reduced by about 80 cars.

c) Examination of parking capacity in the town center

Shortage of the parking capacity caused by factors described in paragraphs a) and b) above is estimated as about 400 cars at maximum.

On the other hand, provision of public parking areas is being planned by the Brunei government and B.S.B. Municipality in the town center. Those are to construct a multi-storied parking building at the site of the fish market and to construct a parking area filling the river behind a mosque. When both plans are materialized, the parking capacity will increase by about 700 cars.

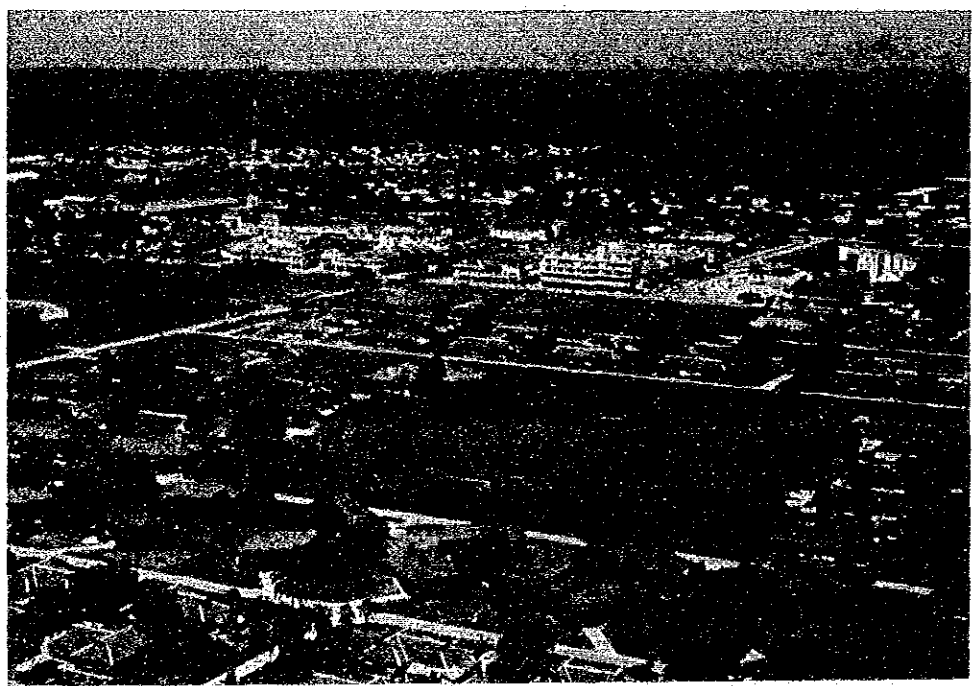
Under these circumstances, the conclusion is that additional provision of parking areas as a part of this project is unnecessary to maintain the present service level.

Table 7-12 Total Construction Cost by Alternative

(Unit: million B$)

Item	Alt 1	Alt 2	Alt 3	Alt 4
Bus System	-	23.20	19.41	19.41
Bus Terminal	-	2.02	1.77	1.77
Bus Stop	-	7.40	7.40	7.40
Bus Operation Office	-	8.39	6.71	6.71
Workshop	-	3.47	1.73	1.73
F/S, D/D, S/V	-	1.92	1.80	1.80
Road System	339.0	109.3	109.3	122.2
Road	292.6	89.8	89.8	101.9
Grade Separate Intersection	27.1	13.6	13.6	13.6
F/S, D/D, S/V	19.3	5.9	5.9	6.7
Total	339.0	132.5	128.7	141.6

CHAPTER 8
EVALUATION OF ALTERNATIVE PLANS



CHAPTER 8 EVALUATION OF ALTERNATIVE PLANS

8-1 Methodology

Economic viability of each Alternative Plan was evaluated under the conventional cost-benefit analysis. The contribution to the national economy in terms of development investment was appraised. The following are the major preconditions in the economic evaluation:

(1) Project life

Implementation would be commenced in the middle of 1986 and the year of opening was set at the same year. Basically, the benefits of Alternative Plans were counted for 10 years after the opening, with the consideration that the service life of buses by 10 years. Project life was thus fixed to be from 1986 to 1995. However, supplementary calculation of costs/benefits was conducted for 20 years up to 2005.

(2) Discount rate

The discount rate for the evaluation was 12%. It was determined from the interview results in Brunei during Phase I of the Study. According to the interviews with Banks' managers, the prime rate (minimum rate) in commercial loans is 10% at the moment, but the annual interest of ordinary loans to the individuals for car purchasing is 13% as of October 1984. The "Bandar Seri Begawan Transport Study" in 1981 used the same 12%. Based on these facts, 12% was selected to apply.

(3) Base year

The base year for the evaluation was fixed at 1986. All the discounted figures of costs and benefits were compounded to the point of 1986, transformed into the present values.

(4) Prices

All the costs and benefits were indicated at constant prices of mid-1984.

Although the ordinary evaluation for transport projects takes the project life of 15 - 20 years, the above preconditions were set due to the inclusion of bus transport system.

In the first step of economic evaluation, economic costs and benefits would be calculated. Economic costs were estimated from the financial costs of Alternative Plans (See Chapter 7), after deducting transfer components in view of the national economy. Benefits were calculated in the procedures as shown in the succeeding Section.

The next step was the annualization of economic costs and benefits. Temporary scheduling in construction and bus procurement was made and all the economic costs and benefits were reduced into the continual annual flows between 1986 and 1995. Capital cost for the facility construction was transformed into annual disbursement and operation/maintenance costs and benefit were calculated as annual values. The flows of costs and benefits became the sources in the economic evaluation.

In the third step, the total economic cost (C) and the total economic benefit (B) were calculated, making use of the discount rate 12%; the calculation was made as shown below.

$$C = \Sigma C_n / 1.12^n$$

$$B = \Sigma B_n / 1.12^n$$

, where C_n : Annual economic costs after n years from 1986

B_n : Annual economic benefits after n years from 1986

C and B are the present values of costs and benefits, respectively, in the year 1986 at constant prices of mid-1984.

The fourth step was the calculation of key indicators for evaluation. These comprise Benefit-Cost Ratio (B/C), Net Present Value (NPV, B-C) and Economic Internal Rate of Return (EIRR). When B/C is over 1.0 or NPV is higher than 0.0, it is justified that social benefits surpass the required costs of the Alternative Plan. The higher these are, the more justification is placed on the implementation of the Plan. EIRR is a discount rate in case of B/C = 1.0 or NPV = 0.0. It makes the totals of both cost and benefit streams equal, showing how fast the invested costs are recovered. The earning magnitude and attractiveness of an Alternative are measured by this EIRR, in general. In this Study, if EIRR is higher than 12%, the contribution to the national economy is likely to be well enough to justify the use of resources.

In comparing the indicators mentioned above, an optimum Alternative Plan was selected. At the final stage of evaluation, EIRR had a dominant influence in decision. The first screening of Alternatives was conducted with the comparison of B/C and NPV.

To the selected optimum Alternative, sensitivity tests of EIRR were carried out, in response to the cost increase and benefit decrease. Additionally, the elasticity of EIRR was scrutinized. The tenability of implementation of the optimum Plan was examined by these analyses.

8-2 Benefit Calculation

The economic benefits brought by the Alternative Plans were firstly considered to consist of 4 kinds of benefit components. The basic concepts of each component are described below.

Road user's benefits

Road user's benefits are defined as the savings of road user's costs which are required in the use of road facilities. The road user's costs usually include vehicle operating costs and passengers' time costs. Therefore, 2 kinds of benefits are to be counted; namely:

- Savings of vehicle operating costs
- Savings of passengers' time costs

Benefits relative to parking

Defined as the savings of parking expenses, mainly with the decrease in parking volume of passenger cars. The parking volume would be calculated in the future traffic conditions.

Savings of costs for passenger car ownership

With the introduction of the public transport system, the total volume of passenger cars owned would be decreased. In proportion to this decrease, the costs for purchasing and holding passenger cars would also be reduced. The savings of these costs would appear as benefits.

Each benefit component would be calculated as the savings, difference of the said costs, between Alternative 0 (fundamental case without project) and Alternatives 1, 2, 3 and 4 (with projects), respectively.

Preliminary calculation was made with rough figures and it has been revealed that the road user's benefits would suffice for the economic evaluation. Furthermore, considered were the following reasons to exclude the latter 2 benefit components:

- Construction costs of parking facilities were not prepared in Chapter 7, as additional facility requirements are nil for the future. The problem area only covers around the town center of BSB. The effects to reduce parking volume would be low and it would not form the major portion of economic benefits.

- It is difficult to determine the relationship between the reduced volume of traffic demand and actual ownership of passenger cars, mainly due to the lack of data. The actual volume of passenger car holdings could not be calculated for this reason.

In this consequence, the economic benefits were calculated in the form of road user's benefits only; namely savings of vehicle operating costs and those of passengers' time costs.

8-2-1 Vehicle Operating Costs in Standard Conditions

The vehicle operating costs are composed of the components as shown below.

(1) Fuel cost
(2) Engine oil cost
(3) Tyre and tube cost
(4) Repair and maintenance cost
(5) Depreciation cost (running distance-related portion)

(6) Overhead cost (only for bus and truck)
(7) Crew cost (only for bus and truck)

Each cost component was calculated for standard conditions which are at benchmark speed or lifetime speed on the standard paved roads in Brunei. The cost components in the items (1), (2) and (4) above were calculated at benchmark speed, while the average lifetime speed was applied to (3), (5), (6) and (7).

To meet the classification in the traffic survey, 3 major divisions of the vehicle types were set off; that is, passenger car (including taxi), bus and truck. Bus and truck were further divided into mini-bus and standard size bus and midium and heavy trucks, respectively. The benchmark speed is 80 km/hour for passenger car and 72 km/hour for bus and truck. The average lifetime speed is taken at 56 km/hour for all the vehicles.

Based on the road-side observation and interviews with car-dealers and insurance companies in Brunei, a representative vehicle was determined by type. Table 8-1 summarizes the basic characteristics of the selected representative vehicles, with the additional information for taxi.

Table 8-1 Standard Vehicle Types in Brunei

Particulars	Passenger Car	(Taxi)	Bus		Truck	
			Mini-bus	Standard	Midium	Heavy
1. Representative Vehicle as Selected	Toyota Carina Saloon	Toyota Cres-sida Saloon	Daihatsu Bus	Mitsubishi Fuso Bus	Daihatsu Truck	Isuzu TXD Tipper Truck
2. Displacement (Engine Capacity)	1,600 cc	2,000 cc	3,000 cc	6,600 cc	3,000 cc	5,800 cc
3. Capacity/ Loadings	5 passengers	5 passengers	20 passengers	45 passengers	2 tons	8 tons
4. Cost on Road (Selling Price)	B$ 14,250	B$ 20,600	B$ 27,000	B$ 84,000	B$ 23,000	B$ 48,500

For bus and truck, the proportion of each sub-division of vehicle types was required. In case of bus, 21% of mini-bus and 79% of standard size bus were determined from the registration record at the LTD as of 1984. On the other hand, the composition of truck was fixed; 34% of medium and 66% of big-size, according to the sales volume in 1983 provided from car dealers.

The calculation of 7 cost components was carried out as shown below. Each component value was obtained in the unit cost of B$/km.

(1) Fuel cost

Major factors having influences to fuel cost calculation are fuel type of vehicle engines (gasoline or diesel) and fuel consumption rate by vehicle type and unit selling price by fuel type. The former 2 information were provided by car dealers, and selling prices per gallon of gasoline and diesel oil were obtained from the interview to gas stations.

The selling price per gallon was B$2.15 for super gasoline, B$1.80 for regular gasoline and B$1.40 for diesel oil. In Brunei, almost all fuel for vehicles comprise super gasoline and regular is mainly for the use of boats/ vessels. In the selling price of fuel, a tax component is included (import duty; ₵10/gallon). However, an almost equal amount of transport subsidies seems to be granted to the government officers in the form of fuel consumption allowance. The selling prices of fuel were thus used as it is in the calculation.

The fuel cost by vehicle type, together with the relevant data, is shown below.

Item (unit)	Passenger	Bus		Truck	
	Car	Mini-bus	Standard	Medium	Heavy
1. Fuel Type	Petrol	Petrol	Diesel	Petrol (50%) Diesel (50%)	Diesel
2. Fuel Consumption (miles/gallon)	30	20	20	15	11
3. Fuel Price (B$/gallon)	2.15	2.15	1.40	2.15 (50%) 1.40 (50%)	1.40
4. Fuel Cost (B$/mile)	0.0717	0.1075	0.0700	0.1183	0.1273
5. Fuel Cost (B$/km)	0.0446	0.0484		0.0772	

(2) Engine oil cost

Monthly oil cost by vehicle type and data for annual running distance were obtained from car dealers. The tax components included (import duty: ₵20/gallon for lubricating oil and ₵5/gallon for lubricating grease) were considered to be nil for the same reason as in the calculation of the fuel cost. The results are:

Item (unit)	Passenger	Bus		Truck	
	Car	Mini-bus	Standard	Medium	Heavy
1. Annual Running Distance (miles/year)	12,000	28,000	50,000	25,000	30,000
2. Engine Oil Cost Interviewed (B$/month)	6.50	17.00	36.70	17.00	33.75
3. Engine Oil Cost (B$/mile)	0.0065	0.0073	0.0088	0.0082	0.0135
4. Engine Oil Cost (B$/km)	0.0040	0.0053		0.0073	

(3) Tyre and tube cost

Annual average amount of tyre and tube costs by vehicle type were obtained from car dealers and have been revised, taking into consideration the other factors such as the cost used in the "Bandar Seri Begawan Transport Study", 1981.

Item (Unit)	Passenger Car	Bus		Truck	
		Mini-bus	Standard	Medium	Heavy
1. Annual Running Distance (miles/year)	12,000	28,000	50,000	25,000	30,000
2. Tyre and Tube Cost, Revised (B$/year)	180.00	3,000.00	3,000.00	3,000.00	4,000.00
3. Tyre and Tube Cost (B$/mile)	0.0150	0.1071	0.0600	0.1200	0.1333
4. Tyre and Tube Cost (B$/km)	0.0093	0.0435		0.0802*)	

*) Further revised

(4) Repair and maintenance cost

Annual average amount of repair and maintenance costs were provided by car dealers and some adjustments were made towards bus and truck. 40% of labour cost and 60% of spare parts price were assumed in the cost values.

Item (Unit)	Passenger Car	Bus		Truck	
		Mini-bus	Standard	Medium	Heavy
1. Annual Running Distance (miles/year)	12,000	28,000	50,000	25,000	30,000
2. Repair and Maintenance Cost, Revised (B$/year)	400.00	1,500.00	6,000.00	4,600.00	5,700.00
3. Repair and Maintenance Cost (B$/mile)	0.0333	0.0536	0.1200	0.1840	0.1900
4. Repair and Maintenance Cost(B$/km)	0.0207	0.0659		0.1168	

(5) Depreciation cost

Depreciation cost was required only for the portion related to the running distance. Basic data for the calculation include the economic cost (cost net of taxes) of representative vehicles, average service life, annual running distance and the salvage value.

Economic cost of vehicles was calculated from the cost on roads (selling price) minus road tax, registration fee and others. Road tax is levied annually with B$2.25 per 100 cc of engine capacity and the registration fee is B$10.00 for a new car. Selling price of a new car usually involves insurance premium, but it was not reduced considering as the general costs for traffic accidents.

Salvage values were determined from either the selling price of a used car or trade-in prices, both of which were provided from car dealers by vehicle type.

Annual amount of depreciation and interest was calculated using above two prices and average service life. In this case, Capital Recovery Factor (CRF) applied to the economic cost and Sinking Fund Factor (SFF) to salvage values were those at an interest rate of 12%.

The division of the total of depreciation and interest values was made by the first fixation of annual interest. Depreciation amount was further divided into 2, utilizing the ratios of time-related portion and the portion related to running distance; 0.7 to 0.3 for passenger car and 0.3 to 0.7 for both bus and truck.

The results of calculation and original data are as follows:

Particulars	Passenger	Bus		Truck	
	Car	Mini-bus	Standard	Medium	Heavy
1. Displacement (Engine Capacity, cc)	1,600	3,000	6,600	3,000	5,800
2. Annual Running Distance (miles/year)	12,000	28,000	50,000	25,000	30,000
3. Average Service Life (years)	5	6	6	7	8
4. Cost on Roads (B$)	14,250	27,000	84,000	23,000	48,500
5. Cost net of Taxes (B$)	14,200	26,900	83,800	22,900	48,350
6. Salvage Value (B$)	3,000	4,000	8,000	4,000	8,000
7. CRF at 12%	0.2774	0.2432	0.2432	0.2191	0.2013
8. SFF at 12%	0.1574	0.1222	0.1222	0.0991	0.0813
9. Annual Depreciation and Interest (5x7-6x8, B$/year)	3,467	6,053	19,403	4,621	9,164
10. Of which, Interest (5-6/3 B$/year)	2,240	3,187	12,633	2,700	5,169
11. Of which, Depreciation (9-10, B$/year)	1,227	2,236	6,770	1,921	3,995
12. Time-related Depreciation (B$/year)	859 (70%)	670 (30%)	2,031 (30%)	576 (30%)	1,199 (30%)
13. Depreciation Relative to Running Distance (B$/year)	368 (30%)	1,566 (70%)	4,739 (70%)	1,345 (70%)	2,796 (70%)
14. Distance-related Depreciation (13/2, B$/mile)	0.0307	0.0559	0.0948	0.0538	0.0932
15. Distance-related Depreciation (B$/km)	0.0191	0.0538		0.0496	

(6) Overhead cost

The overhead cost for the vehicle operation was counted only for commercial vehicles; namely, bus and truck.

It was assumed that annual amount at average lifetime speed, be 7% of the economic cost for standard size bus, 4% for heavy truck and 2.5% for mini-bus and medium truck.

The calculation results are as shown below.

Item (Unit)	Passenger	Bus		Truck	
	Car	Mini-bus	Standard	Medium	Heavy
1. Annual Running Distance (miles/year)	12,000	28,000	50,000	25,000	30,000
2. Economic Cost of Vehicle (B$)	14,200	26,900	83,800	22,900	48,350
3. Factor to be Multiplied	–	0.025	0.07	0.025	0.04
4. Overhead Cost (B$/year)	–	673	5,866	573	1,934
5. Overhead Cost (B$/mile)	–	0.0240	0.1173	0.0229	0.0645
6. Overhead Cost Cost (B$/km)	–	0.0607		0.0313	

(7) Crew cost

The crew cost was calculated based on the information of bus driver's salary (B$450/month as of October 1984) from the Educational Transport Department and wage data provided by the Labour Department.

These are:

Item (unit)	Passenger	Bus		Truck	
	Car	Mini-bus	Standard	Medium	Heavy
1. Annual Running Distance (miles/year)	12,000	28,000	50,000	25,000	30,000
2. Number of Crew					
- Driver	-	1	1	1	1
- Conductor	-	-	1	-	-
- Labourer	-	-	-	0.5	1
3. Wage (B$/year)	-	5,400	7,800	4,200	6,600
4. Crew Cost (B$/mile)	-	0.1929	0.1560	0.1680	0.2200
5. Crew Cost (B$/km)	-	0.1018		0.1257	

As a summary, thus calculated vehicle operating costs in standard conditions are tabulated in Table 8-2 below.

Table 8-2 Vehicle Operating Cost in Standard Condition

Unit: B$/km

Item of Cost Components	Passenger Car	Bus	Truck
1. Fuel Cost	0.0446	0.0484	0.0772
2. Engine Oil Cost	0.0040	0.0053	0.0073
3. Tyre and Tube Cost	0.0093	0.0435	0.0802
4. Repair and Maintenance Cost	0.0207	0.0659	0.1168
5. Depreciation Cost (Distance-related)	0.0191	0.0538	0.0496
6. Overhead Cost	-	0.0607	0.0313
7. Crew Cost	-	0.1018	0.1257
Total Vehicle Operating Costs	0.0977	0.3794	0.4881

Remarks: Items 1, 2 and 4 above at benchmark speed (80 km/hour for passenger car and 72 km/hour for bus and truck), and 3, 5, 6 and 7 at average lifetime speed (56 km/hour for all vehicle types) on the standard paved roads.

8-2-2 Vehicle Operating Costs in Response to Speeds

Basic estimates of cost components for vehicle operating costs should then be transformed to meet actual contidions. The factors affecting vehicle operating costs includes travelling speed, road surface type, grades, curves and speed change cycle caused by traffic conditions. However, only the travelling speed was considered since all the calculation was made only provisionally for the Master Plan Study.

The conversion factors for the variation of each cost components in response to speeds were quoted from Robley Winfrey's "Economic Analysis for Highways" (International Textbook Company, Scranton, Pennsylvania, USA, 1969) with some modifications. The factors for the respective components are:

(1) Fuel cost

Speed (km/hour)	Passenger Car	Bus	Truck
10	1.3003	1.7529	1.9000
16	1.1502	1.4950	1.5999
24	1.0301	1.2506	1.3200
32	0.9301	1.0401	1.0799
40	0.8699	0.9368	0.9599
48	0.8501	0.8894	0.9016
56	0.8600	0.8858	0.8899
64	0.8899	0.9199	0.9199
72	0.9403	1.0000	1.0000
80	1.0000	1.1078	1.1099
88	1.0701	1.1999	1.1998

(2) Engine oil cost

Speed (km/hour)	Passenger Car	Bus	Truck
10	1.8514	1.7898	1.8864
16	1.5991	1.5699	1.7444
24	1.4505	1.4291	1.6045
32	1.3018	1.2846	1.4625
40	1.2523	1.2240	1.3489
48	1.1981	1.1690	1.2718
56	1.1486	1.1132	1.1785
64	1.1036	1.0541	1.0832
72	1.0541	1.0000	1.0000
80	1.0000	0.9466	0.9432
88	1.0586	1.0850	1.1034

(3) Tyre and tube cost

Speed (km/hour)	Passenger Car	Bus	Truck
10	0.5787	0.5797	0.5797
16	0.5787	0.5797	0.5797
24	0.6068	0.6096	0.6098
32	0.6882	0.6903	0.6897
40	0.7781	0.7802	0.7798
48	0.8876	0.8900	0.8897
56	1.0000	1.0000	1.0000
64	1.1404	1.1399	1.1399
72	1.2893	1.2901	1.2897
80	1.4888	1.4907	1.4899
88	1.7275	1.7305	1.7297

(4) Repair and maintenance cost

Speed (km/hour)	Passenger Car	Bus	Truck
10	0.6499	0.6799	0.6799
16	0.6793	0.7198	0.7200
24	0.7196	0.7598	0.7600
32	0.7497	0.7999	0.7999
40	0.7900	0.8399	0.8400
48	0.8298	0.8799	0.8799
56	0.8695	0.9200	0.9199
64	0.9098	0.9599	0.9600
72	0.9501	1.0000	1.0000
80	1.0000	1.0399	1.0399
88	1.0295	1.0800	1.0800

(5) Depreciation cost

Speed (km/hour)	Passenger Car	Bus	Truck
10	1.0000	3.5585	3.5585
16	1.0000	2.7000	2.6999
24	1.0000	1.9000	1.8999
32	1.0000	1.5584	1.5583
40	1.0000	1.3168	1.3167
48	1.0000	1.1501	1.1499
56	1.0000	1.0000	1.0000
64	1.0000	0.9333	0.9332
72	1.0000	0.8333	0.8333
80	1.0000	0.7500	0.7499
88	1.0000	0.6833	0.6833

(6) Overhead cost

Speed (km/hour)	Passenger Car	Bus	Truck
10	-	4.3411	4.3425
16	-	3.1008	3.1014
24	-	2.3253	2.3261
32	-	1.7439	1.7455
40	-	1.4029	1.4031
48	-	1.1623	1.1629
56	-	1.0000	1.0000
64	-	0.8759	0.8760
72	-	0.7747	0.7753
80	-	0.6975	0.6972
88	-	0.6357	0.6349

It was assumed that crew cost would not vary by the running speed. The fuel cost curve is U-shaped according to running speeds, rising at high and low with the minimum point between 45 and 55 km/hour. Engine oil cost rises at low speeds and the benchmark speed has the lowest value for all the vehicle types. As the tyre wear is a function of the running speed, the cost is higher in the higher vehicle speeds. The coefficient for the tyre and tube cost is almost uniform in all the vehicle types. The cost curve for repair and maintenance is similar to that for tyre and tube but more gradual. Towards passenger cars, the depreciation cost was assumed to be constant. On the contrary, those for bus and truck are higher at the lower speeds. The overhead cost involves a conception of time cost; it is higher at lower speeds.

The vehicle operating costs at the various speeds were calculated through the multiplication between those in standard conditions and the conversion factor by cost component and further through the summation of the converted components' values. In this calculation, only the selected running speeds were taken because of the difficulty of applying all the continuous running speeds. Table 8-3 gives calculation results of these vehicle operating costs at the selected running speeds.

Table 8-3 Vehicle Operating Costs at Selected Speed

Unit: B$/km

Running Speed (km/hour)	Passenger Car	Bus	Truck
10	0.1034	0.7210	0.7245
16	0.0957	0.5886	0.6467
24	0.0913	0.4897	0.5518
32	0.0877	0.4287	0.5004
40	0.0865	0.3988	0.4794
48	0.0873	0.3802	0.4722
56	0.0881	0.3692	0.4715
64	0.0926	0.3682	0.4818
72	0.0969	0.3693	0.4960
80	0.1022	0.3752	0.5183
88	0.1084	0.3876	0.5450

8-2-3 Savings of Vehicle Operating Costs in 1995

The vehicle operating costs by Alternative Plan would be obtained from the projected traffic volume (vehicles.km) by speed and the vehicle operating costs at the respective running speeds by vehicle type. Savings of vehicle operating costs of Alternative 1, 2, 3 and 4 would be calculated as the difference of the respective costs from those of Alternative 0.

The traffic volume of each Alternative in 1995 was already forecasted in Chapter 6. Tables 8-4 to 8-8 show the daily traffic volume by Alternative Plan obtained for the yaer 1995.

Table 8-4 Traffic Volume of Alternative 0

Unit: Vehicles·km x 10^3/day

Range of Running Speeds (km/hour)	Passenger Car	Bus	Truck
0 - 20	917.5	4.5	210.6
20 - 30	302.2	4.5	91.3
30 - 40	78.5	0.3	17.1
40 - 50	431.2	3.5	122.4
50 - 60	138.0	0.4	35.3
60 - 70	679.4	6.1	156.8
70 - 80	150.5	-	32.0
80 - 90	-	-	-
Total	2,697.2	19.2	665.4

Table 8-5 Traffic Volume of Alternative 1

Unit: Vehicles·km x 10^3/day

Range of Running Speeds (km/hour)	Passenger Car	Bus	Truck
0 - 20	253.4	0.4	47.0
20 - 30	266.8	4.3	84.5
30 - 40	192.8	-	37.1
40 - 50	428.9	3.4	106.3
50 - 60	385.6	1.4	85.9
60 - 70	820.0	10.2	199.9
70 - 80	123.6	-	50.9
80 - 90	127.2	-	31.6
Total	2,598.2	19.7	642.1

Table 8-6 Traffic Volume of Alternative 2

Unit: Vehicles·km x 10^3/day

Range of Running Speeds (km/hour)	Passenger Car	Bus	Truck
0 - 20	238.0	5.3	69.4
20 - 30	51.7	2.4	15.1
30 - 40	247.6	4.7	95.5
40 - 50	590.5	15.5	169.4
50 - 60	194.7	3.9	56.8
60 - 70	802.5	19.9	226.6
70 - 80	-	-	-
80 - 90	-	-	-
Total	2,124.9	51.7	632.9

Table 8-7 Traffic Volume of Alternative 3

Unit: Vehicles·km x 10^3/day

Range of Running Speeds (km/hour)	Passenger Car	Bus	Truck
0 - 20	269.7	4.9	75.9
20 - 30	176.5	3.8	59.4
30 - 40	266.7	5.2	85.6
40 - 50	635.4	12.5	175.4
50 - 60	57.9	1.9	18.3
60 - 70	815.2	18.9	219.8
70 - 80	-	-	-
80 - 90	-	-	-
Total	2,221.4	47.3	634.5

Table 8-8 Traffic Volume of Alternative 4

Unit: Vehicles·km x 10^3/day

Range of Running Speeds (km/hour)	Passenger Car	Bus	Truck
0 - 20	303.4	2.6	72.5
20 - 30	287.1	5.5	100.9
30 - 40	48.3	0.5	12.5
40 - 50	699.3	10.2	181.0
50 - 60	118.0	4.4	29.4
60 - 70	922.8	15.9	236.9
70 - 80	-	-	-
80 - 90	-	-	-
Total	2,378.9	35.2	633.1

In the actual calculation, the further modifications were made to what has been calculated in the previous Sub-section 8-2-2. Major 2 points of the modification of vehicle operating costs are:

(1) Fixation of representative speeds and revision of the costs

Since the future traffic volume was given by range, the representative running speed in each range was determined appropriately; whereby revising the value of the costs.

Range of Running Speed (km/hour)	Representative Speed (km/hour)	Vehicle Operating Costs(B$/km)		
		Passenger Car	Bus	Truck
0 - 20	10	0.1034	0.7210	0.7245
20 - 30	24	0.0913	0.4897	0.5518
30 - 40	36	0.0871	0.4138	0.4899
40 - 50	44	0.0869	0.3895	0.4758
50 - 60	56	0.0881	0.3692	0.4715
60 - 70	64	0.0926	0.3682	0.4818
70 - 80	76	0.0996	-	0.5072
80 - 90	84	0.1053	-	0.5317

(2) Deduction of conductor's wage and depreciation component from bus operating cost for Alternatives 2, 3 and 4

The conductor's wage (fixed at constant by speed: B$0.0233/km) and depreciation cost were excluded in case of Alternatives 2, 3 and 4. It was due to the following considerations:

- These 3 Alternatives are essentially for the improvement of public bus operation, in which the project costs include those for the bus procurement.
- The buses proposed in these Alternatives are with improved conditions and to be with one-man operation equipment. The crew would be only one driver.

The following are the comparison of the applied bus operating costs between Alternative 1 and these 3 Alternatives:

Representative Speed (km/hour)	Vehicle Operating Cost for bus (B$/km)	
	Alternative 1	Alternatives 2, 3 and 4
10	0.7210	0.5063
24	0.4897	0.3642
36	0.4138	0.3132
44	0.3895	0.2999
56	0.3692	0.2921
64	0.3682	0.3064
76	-	-
84	-	-

The calculation results of savings of vehicle operating costs are summarized in Table 8-9.

Table 8-9 Savings of Vehicle Operating Costs by Alternative Plan, 1995

Unit: B$$10^6$/year

Alternative Plan	Total Savings of Vehicle Operating Costs
Alternative 1	24.6
Alternative 2	39.9
Alternative 3	34.9
Alternative 4	30.4

8-2-4 Savings of Passengers' Time Costs in 1995

Savings of passengers' time costs were counted only for passenger cars and buses; trucks were excluded. Time costs would be calculated using the projected travel time (vehicle. hour) and the passengers' time value by vehicle type. Savings of the time costs of an Alternative are derived from the difference of costs with Alternative 0.

The travel time of passenger cars and buses in 1995 has already been obtained in the traffic demand forecasting as shown in Table 8-10.

Table 8-10 Travel Time of Alternatives, 1995

Unit: Vehicle · hour x 10^6/year

Alternative Plan	Travel Time	
	Passenger Car	Bus
Alternative 0	75.2	0.5
Alternative 1	34.3	0.2
Alternative 2	30.1	0.8
Alternative 3	32.8	0.7
Alternative 4	34.3	0.5

The most important aspect in the cost calculation is the determination of passengers' time value which means the amount passengers would like to pay for the savings of travel time. This time value was obtained from the passengers' income in unit time.

From the results of the traffic survey, the relevant data were prepared as follows:

Type of Vehicles	Monthly Income (B$)	Hourly *) Income (B$)	Number of Passengers (persons)
Passenger Car (including Van)	1,402.00	6.82	1.8
Bus	487.00	2.38	20.0

Remarks; *): By dividing monthly income with number of weeks of a month (4.29), and further with weekly working hours (48 hours).

Unit : %

Trip Purposes	Composition	
	Passenger Car	Bus
1. Work	29.9	23.4
2. Business	9.6	4.3
3. Home	29.6	42.1
4. School	4.3	7.5
5. Others	26.6	22.7

Remarks; Number of respondents:

Passenger car : 7,526 persons

Bus : 836 persons

The income level of bus passengers is low compared to that for passenger cars; it is due to the inclusion of a number of immigrant workers and the persons without job such as students and the aged.

The average earnings of 1 passenger in 1 hour were calculated taking the trip purposes into consideration, under the following assumptions:

- Business trip : 100% of the hourly income is earned.
- Trips for work : 50% of the hourly income is earned.
- Trips to home : 25% of the hourly income is earned.
- School/Others : No value

The average earned amount per person or per vehicle was obtained as shown below.

Unit : B$/hour

Vehicle Type	Average Earnings per Passenger per Hour					Number of Passengers	Earnings per Vehicle per Hour
	Work*	Business*	Home *	Others	Total		
Passenger Car	1.0196	0.6547	0.5047	-	2.1790	(1.8)	3.92
Bus	0.2785	0.1023	0.2505	-	0.6318	(20.0)	12.63

Remarks; * : These were calculated from the hourly income by multiplying the composition of trip purposes and the proportion assumed as shown above by trip purpose.

Earnings per hour by vehicle type are the sources for the determination of passengers' time value; it is merely the income increment in unit time. Passengers will not pay usually as much as the amount of their earnings in order to save the travel time. In ordinary cases, the time value is set as half of the amount earned by passenger. Following this ordinary principle, the time value of a passenger car would be B$1.96/vehicle.hour and that of a bus B$6.31/vehicle.hour.

However, to the passenger car, the further reduction of value was required from the review of traffic survey data and method. It was clarified that the income data for passenger cars were those only of the drivers. It is probable for the co-passengers to have the lower income than drivers or to earn no money because of the family membership. After the considerations to these, the original value of passenger cars was reduced into a quarter (1/4) as an average time value (B$0.98/vehicle.hour).

The actual time value used for buses, was altered according to Alternative Plans; from the similar reason to the vehicle operating costs. Towards Alternative 2, 3 and 4, the assumption was set that almost all bus passengers shift from those of passenger cars. The passenger cars' unit value was applied to these Alternatives taking the change of trip purpose composition into consideration. For the Alternatives 2, 3 and 4, B$9.05/vehicle.hour was thus used in the actual calculation.

Table 8-11 Vehicle Time Values Applied to Alternatives

Unit : B$/Vehicle·hour

Alternative Plan	Passenger Car	Bus
Alternative 0	0.98	6.31
Alternative 1	0.98	6.31
Alternative 2	0.98	9.05
Alternative 3	0.98	9.05
Alternative 4	0.98	9.05

The multiplication, of these time values per vehicle to the projected travel time (vehicle.hour) gave the passengers' time costs by Alternative. Savings of the costs by Alternative were obtained by the deduction of the respective costs from those of Alternative 0. Table 8-12 shows the calculation results of savings of passengers' time costs by Alternative for the year 1995.

Table 8-12 Savings of Passenger's Time Costs, 1995

Unit : B$10^6

Alternative Plan	Savings
Alternative 1	42.0
Alternative 2	40.2
Alternative 3	38.5
Alternative 4	38.1

8-2-5 Benefit Streams of Alternative Plans

In the abovementioned benefit calculation, the econimic benefits only in 1995 were obtained. To make benefit flow between 1986 and 1995, another devices would have to be employed. Before the annualization, the calculated economic benefits are summarized in Table 8-13.

Table 8-13 Economic Benefits by Alternative, 1995

Unit: B$10^6

Alternative Plan	Savings of the Costs (Benebit)		
	Vehicle Operating Costs	Passengers' Time Costs	Total
Alternative 1	24.6	42.0	66.6
Alternative 2	39.9	40.2	80.1
Alternative 3	34.9	38.5	73.4
Alternative 4	30.4	38.1	68.5

With a view to making benefit flow for 10 years, a temporary scheduling of the implementation was made by Alternative. Owing to the difficulty of the smooth shift from passenger cars to public bus transport, it was assumed that all the benefits appear from 4 years after the opening in case of Alternative 2, 3 and 4 which contain the improvement of bus operation. The major reason for this assumption was the gradual permeation of the bus service improvement into people's mind. The first effects of these Alternative Plans would occur in the year 1990; furthermore, half of the economic benefits in 1995 was assumed to appear this year.

Alternative 1 is composed of only the road construction for reducing traffic congestion, successively to the projects planned for the 5th NDP Period, 1985 - 1989. Considering construction schedule precisely, it was assumed that appearance of the economic benefits of this Alternative would not take place until 1990; however, the amount to be expected in 1990 would be high compared with the other Alternatives. The successive construction works would give the more huge effects in this Alternative. The benefits were assumed to appear in proportion to the person trip increase. The forecasted volume of person trips in 1995 was 1.691 times of those in 1984. As a result, it was assumed that 76.8% of the economic benefits in 1995 would be attained in 1990.

Between 1990 and 1995, the continuous increase in the economic benefits would be assumed. Table 8-14 tabulates the benefit stream obtained under these assumptions.

Table 8-14 Economic Benefits by Alternative, 1986 – 1995

Unit : B$$10^6$

Year	Alternative-1	Alternative-2	Alternative-3	Alternative-4
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	-	-
1990	51.1	40.1	36.7	34.3
1991	53.9	46.1	42.2	39.4
1992	56.8	52.9	48.4	45.2
1993	59.9	60.7	55.6	51.9
1994	63.2	69.7	63.9	59.7
1995	66.6	80.1	73.4	68.5

8-3 Estimation of Economic Costs

The financial costs of each Alternative Plan have been already obtained in Chapter 7, as preliminary estimates. These may include the transfer components such as import duty, tax, insurance fee and interest, which have no meaning in view of the national economy. The transfer components would have to be deducted to obtain the economic costs of Alternatives. After deducting these components, the economic costs would be annualized into the flow between 1986 and 1995. The actual procedures are mentioned below in each Alternative.

Alternative 1

As mentioned earlier, this Alternative involves only the road construction. The total financial costs have been estimated to be B$339.0 x 10^6. For annualizing capital investment, a temporary schedule was made; that is:

1986 and 1987 : Detail design stage; no construction works.

1988 to 1992 : Construction stage; all the works would be accomplished in the year 1992.

Out of the total capital investment, the disbursement at the first stage for D/D does not contain any transfer component. It was assumed that B$4.0 x 10^6 be allocated for 1986 and B$5.9 x 10^6 for 1987, respectively.

- Heavy machineries are frequently used in road construction. The market prices of these include 15 - 20% amount of the levied import duties.
- The right-of-way costs occupy almost one-third of the capital costs in this Alternative. Sometimes roads pass by the barren land which has no value of the other economic activities. The economic costs might not be counted in such the case.
- The land to be acquired for the right of way would include the government land which requires almost no cost for compensation.

Considering these, around 10% reduction was made. The economic costs for construction were thus assumed to be B$296.0 x 10^6 in total, being disbursed with B$59.2 x 10^6 annually during the construction period from 1988 to 1992.

Operation and maintenance costs would be required for the completed roads. These were assumed to be 0.3% of the capital investment costs, based on the following investigations:

- According to the disbursement figures in 1982, the operation and maintenance costs for the existing roads are B$11 x 10^3/km. (Total Road Length: 641,657 miles, Total O/M Costs: BS$11,351 x 10^3).

- The past trend of O/M cost disbursement was almost constant year by year. (These were provided from the PWD). The same amount of O/M costs per km was assumed to be disbursed even in the future.

- To the construction cost for the standard road (B$3,500 x 10^3) this unit O/M cost per km corresponds to 0.3% in amount.

The operation and maintenance costs would appear from the next year of the capital cost disbursement. These do not include transfer components.

Table 8-15 shows the annualized economic costs of Alternative 1 from 1986 to 1995.

Table 8-15 Annualized Economic Costs of Alternative 1

Unit : B$$10^6$

Year	Costs for D/D and Engineering	Construction Costs	Operation/ Maintenance Costs	Total
1986	4.0	-	-	4.0
1987	5.9	-	-	5.9
1988	-	59.2	-	59.2
1989	-	59.2	0.2	59.4
199C	-	59.2	0.4	59.6
1991	-	59.2	0.5	59.7
1992	-	59.2	0.7	59.9
1993	-	-	0.9	0.9
1994	-	-	0.9	0.9
1995	-	-	0.9	0.9
Total	9.9	296.0	4.5	310.4

Alternative 2

This Alternative Plan comprises 2 major fields of investment; namely, road construction and provision of public bus transport. Individual annualization was conducted in either the field.

For the road construction (total finacial costs being estimated; B$109.3 x 10^3), similar considerations to Alternative 1 were taken. Costs for detail design and engineering would be disbursed with B$1.4 x 10^6 in 1986 and B$1.5 x 10^6 in 1987. The capital investment reduced with 10% of transfer components (total construction costs: B$96.0 x 10^6) would be allocated equally with the annual amount of B$19.2 x 10^6 for 5 years during 1988 to 1992. Operation and maintenance costs for the completed roads were also calculated.

The investment to the public bus system is further divided into 2, which are for the bus procurement and construction of the facilities concerned with bus operation.

To the bus procurement, a temporary bus purchasing schedule was considered under the following assumptions:

- Total number of required buses is 340 in 1995. Over 68% of this total would be purchased by the year 1990. The gradual increase of operating buses are necessary for 10 years. The number of operating buses were thus fixed at 145 in 1986 and 235 in 1990.

- The newest models of the existing buses (total number: 175 as of 1984) are those produced in 1984. Assuming the service life of buses to be 6 to 7 years, all of these shall retire from the services around the year 1990.

- In the first 3 years, the existing buses would be available for the supplement to the bus procurement.

Purchasing schedule of the bus was temporarily determined as follows.

Year	Number of Buses to be Purchased
1988	70
1989	165
1991	60
1993	45

The unit cost for purchasing a bus is B$92,000 (CIF price at Muara Port) with the improved conditions such as air-conditioner and one-man bus equipments installed. No tax component is included in the CIF prices. Total costs for bus purchasing would be:

Unit: B$$10^6$

Year	Costs for Bus Procurement
1988	6.4
1989	15.2
1991	5.5
1993	4.1

The facilities related to bus operation consist of bus terminals, bus-stops, bus operation offices and workshop. Total financial costs for construction have been estimated to be B$23.2 x 10^6, of which B$0.9 x 10^6 is for detail design and preliminary engineering in 1986 and 1987. The other construction costs of B$22.3 x 10^6 would be disbursed in 1988, 1989 and 1990, almost equally in annual amount. No transfer component was assumed to these costs.

Although the operation and maintenance costs were considered for the road portion, these were excluded in the bus-related facilities, which would be completed in 1990. It was because the vehicle operating costs involve both operating costs of buses and operation and maintenance costs of the facilities. If these be included, the double counting of the same components would be unavoidable.

A stream of thus calculated economic costs of Alternative 2 is shown in Table 8-16

Table 8-16 Annualized Economic Costs of Alternative 2

Unit : $B\$10^6$

Year	Road Portion			Public Bus System		Total
	Study/Design	Construction	O/M	Procurement	Facilities	
1986	1.4	-	-	-	0.4	1.8
1987	1.5	-	-	-	0.5	2.0
1988	-	19.2	-	6.4	7.4	33.0
1989	-	19.2	0.1	15.2	7.4	41.9
1990	-	19.2	0.1	-	7.5	26.8
1991	-	19.2	0.2	5.5	-	24.9
1992	-	19.2	0.2	-	-	19.4
1993	-	-	0.3	4.1	-	4.4
1994	-	-	0.3	-	-	0.3
1995	-	-	0.3	-	-	0.3

Alternative 3

Basically employed were the same concepts as in Alternative 2 for the deduction of transfer components and for the annualization of economic costs. The purchasing schedule of buses and the calculated economic costs were based on the assumed requirements of operating buses of 160 in 1990 and 235 in 1995, as follows:

Year	Number of Buses	Required Costs ($B\$10^6$)
1988	45	4.1
1989	115	10.6
1991	45	4.1
1993	30	2.8

Remarks: The same CIF price of the bus was applied as in Alternative 2

Annualized economic costs of Alternative 3 are found in Table 8-17.

Table 8-17 Annualized Economic Costs of Alternative 3

Unit : B$$10^6$

Year	Road Portion			Public Bus System		Total
	Study/Design	Construction	O/M	Procurement	Facilities	
1986	1.4	-	-	-	0.4	1.8
1987	1.5	-	-	-	0.4	1.9
1988	-	19.2	-	4.1	6.2	29.5
1989	-	19.2	0.1	10.6	6.2	36.1
1990	-	19.2	0.1	-	6.2	25.5
1991	-	19.2	0.2	4.1	-	23.5
1992	-	19.2	0.2	-	-	19.4
1993	-	-	0.3	2.8	-	3.1
1994	-	-	0.3	-	-	0.3
1995	-	-	0.3	-	-	0.3

Alternative 4

Annualized economic costs were obtained in the similar way to the aforementioned procedures, as shown in Table 8-18. Bus purchasing was assumed to be 30 in 1988, 80 in 1989, 30 in 1991 and 20 in 1993.

Table 8-18 Annualized Economic Costs of Alternative 4

Unit : B$$10^6$

Year	Road Protion			Public Bus System		Total
	Study/Design	Construction	O/M	Procurement	Facilities	
1986	1.6	-	-	-	0.4	2.0
1987	1.7	-	-	-	0.4	2.1
1988	-	21.4	-	2.8	6.2	30.4
1989	-	21.4	0.1	7.4	6.2	35.1
1990	-	21.4	0.1	-	6.2	27.7
1991	-	21.4	0.2	2.8	-	24.4
1992	-	21.4	0.3	-	-	21.7
1993	-	-	0.3	1.8	-	2.1
1994	-	-	0.3	-	-	0.3
1995	-	-	0.3	-	-	0.3