3) MRT Demand from Airport

One of the MRT stations drops in the Simon Bolivar international airport and then its access passengers are expected to be divereted to the MRT. Total access passenger volume to the airport is shown in Table 4-2.5.

The airport access is now made by 3 modes; private vehicles, taxis and buses and each share was estimated by the airport survey as shown in Table 4-2.6. The airport passenger trend is almost changeless at 3,000 a day for these years and their access heavily depends upon private transport, private cars and taxi.

The future MRT demand from the airport is estimated about 300 persons a day, assuming that the future passenger volume would maintain the same level and the bus access would turn to the MRT.

4-3 Demand for Each Case in Route and Section

The MRT demand for the test cases is estimated in each route and section in the same method.

1) Demands in Route Alternatives

The Team set the 2 route alternatives;

Route I : The route passes Av. de las Americas from the airport to the CBD.

Route II : The route passes Av. San Jorge and Av. Kennedy for the above section.

Both routes have almost same characteristics in origin, destination and route length, but differ in relation to the bus route organization. The space in front of each station along Av. de Las Americas in route I is not enough to provide necessary bus berths and thus it is almost impossible to connect the bus route to the MRT.

Table 4-2.5 TRENDS OF AIRPORT PASSENGERS

Unit: Passengers/day

	Year	79	80	81	82	83	85
International	Departure	334	361	352	284	224	324
	Arrival	330	356	347	297	227	295
	Total	664	717	699	581	451	619
Domestic	Departure	1,038	1,197	1,128	1,212	1,227	928
	Arrival	1,932	1,216	1,154	1,286	1,190	896
	Total	1,970	2,413	2,282	2,498	2,417	1,824
Total	Departure	1,372	1,558	1,480	1,496	1,451	1,252
	Arrival	1,262	1,572	1,501	1,583	1,417	1,191
	Total	2,634	3,130	2,981	3,079	2,868	2,443

Table 4-2.6 MODAL CHOICE OF AIRPORT ACCESS

Access mode		No. of samples	Modal share (%)	Modal share (%)
Private vehicles	Passengers car	144	29.7	38.8
	Van	44	9.1	
Taxi	Taxi	251	51.8	53.0
	Hyre	6	1.2	
Bus	Bus	3	0.6	8.2
	Colectivo	22	4.5	
	Buseta	15	3.1	
Total		485	-	-

Source) The airport survey by the Study Team in November 1985

MRT demand for both route alternatives are calculated based on the above consideration and shown in Table 4-3.1.

Table 4-3.1 MRT DEMANDS IN ROUTE ALTERNATIVES

Persons/day

Route Alternatives \ Year	1990
Route I	365,000
Route II	401,000

Note) Demands were estimated only in the year 1990 and Basic Case.

2) Demand Forecast by Section Pattern

The Basic Pattern is divided into 4 patterns of A, B, C and D in accordance with each section of the first stage construction. The demand is forecasted by each section pattern in the same manner applied to the Basic Pattern, and the results of the forecast were obtained as shown in Table 4-3.2.

Comparison of the demands for each section pattern in 1990 accounted for Pattern B > Pattern D > Pattern A > Pattern C in order. As a result, it indicates that this order is proportional to the approximate operating kilometerage of the section corresponding to each section pattern and, as shown in Table 4-3.3, Pattern B becomes greatest in the aspect of demand collection, as well, when the demad per 1 km, per 1 station in each section pattern are compared.

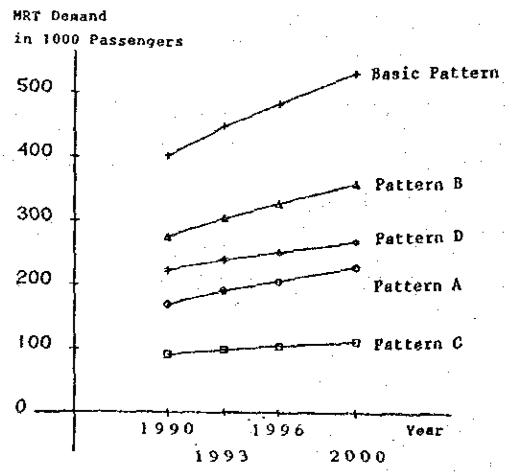


Figure 4-3.1 MRT DEMAND IN FUTURE

Table 4-3.2 MRT DEMAND BY CASE

Item \ Section Pattern		Basic Pattern	Pattern A	Pattern B	Pattern C	Pattern D
Dimension	No. of Stations	12	5	8	5	8
	Section Length (km)	14.7	6.7	9.1	5	8.0
Demand Persons /day)	1990	401,000	170,000	275,000	92,000	223,000
	1993	447,000	191,000	304,000	99,000	239,000
	1996	482,000	206,000	327,000	105,000	251,000
	2000	530,000	228,000	358,000	112,000	268,00

Table 4-3.3 COMPARISON OF MART DEMAND BY CASE

Section	Demand in 1990 (persons/day)	Section Length (km)	Number of Stations	Demand / Section length 1 km	Demand / 1 station
Pattern A	170,000	6.7	5	25,370	34,000
Pattern B	275,000	9.1	8	30,200	34,400
Pattern C	92,000	5.6	5	16,400	18,400
Pattern D	223,000	8.0	8	27,900	27,900

4-4 Demand Forecast for the Test Cases

The demand of MRT is estimated by each Test Case based on demand forecast result for section patterns.

It is shown in Figure 4-4.1.

Figure 4-4.1 MRT DEMAND FORECAST BY TEST CASE

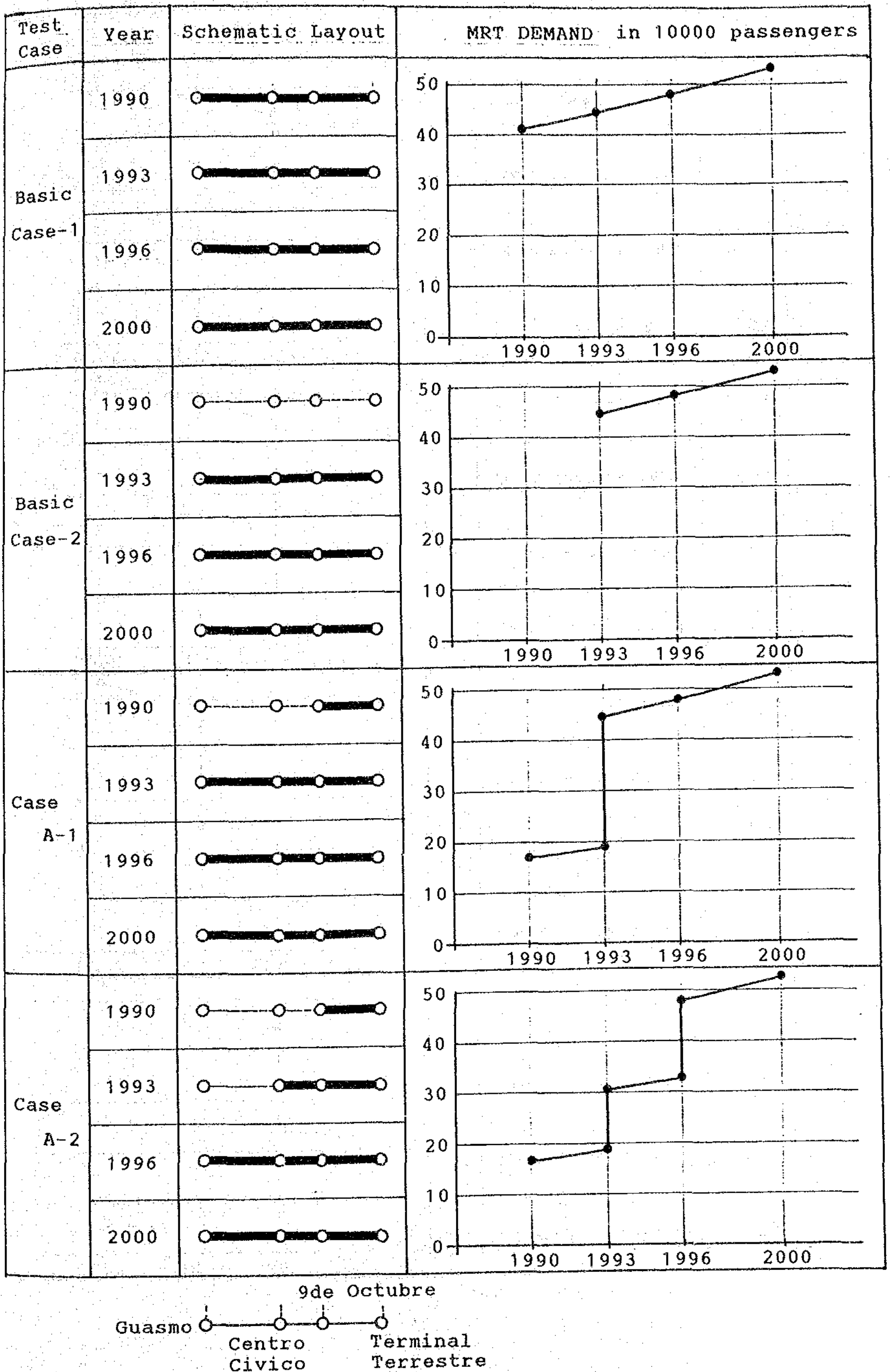


Figure 4-4.1(1) MRT DEMAND FORECAST BY TEST CASE (1)

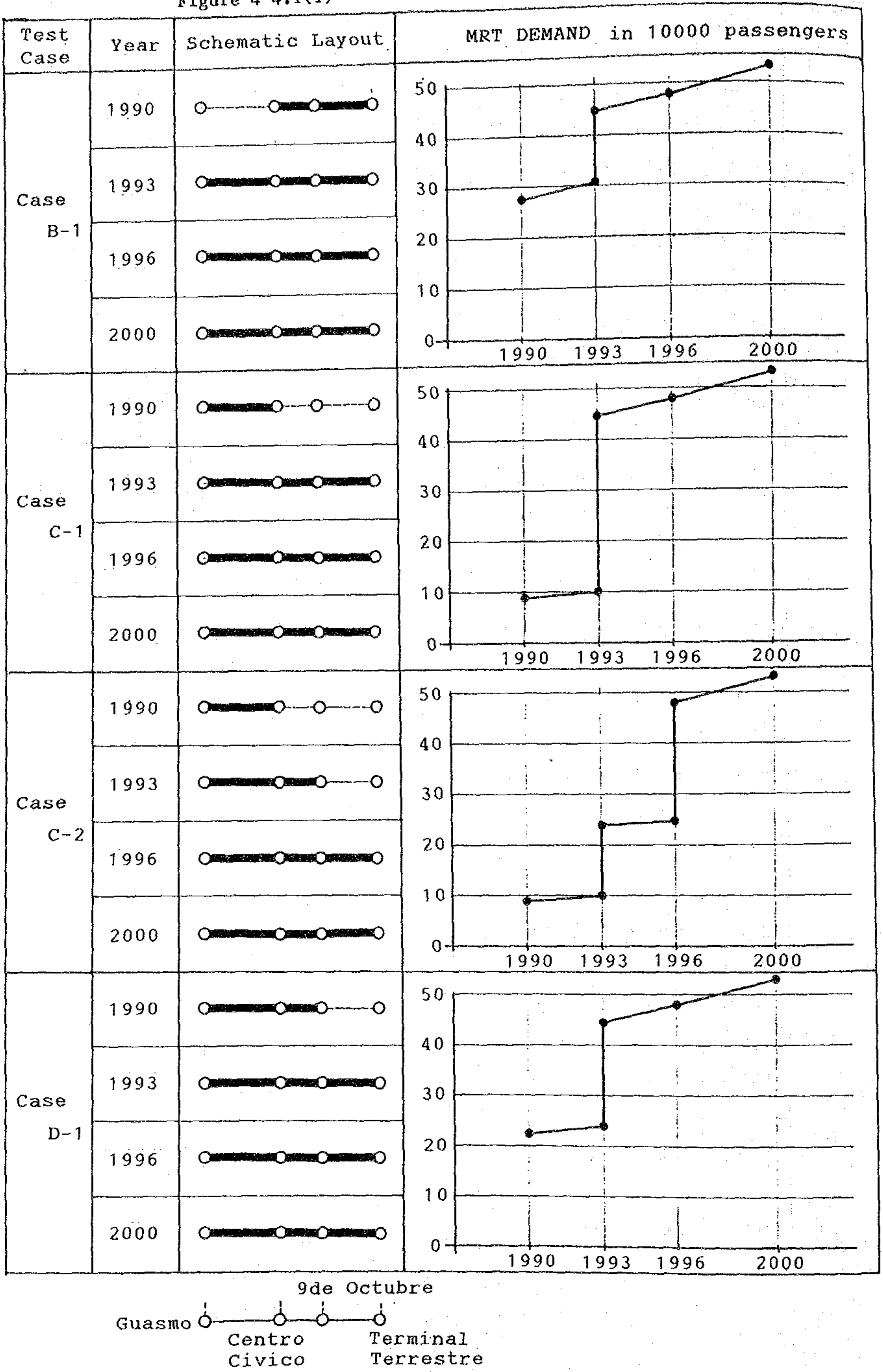
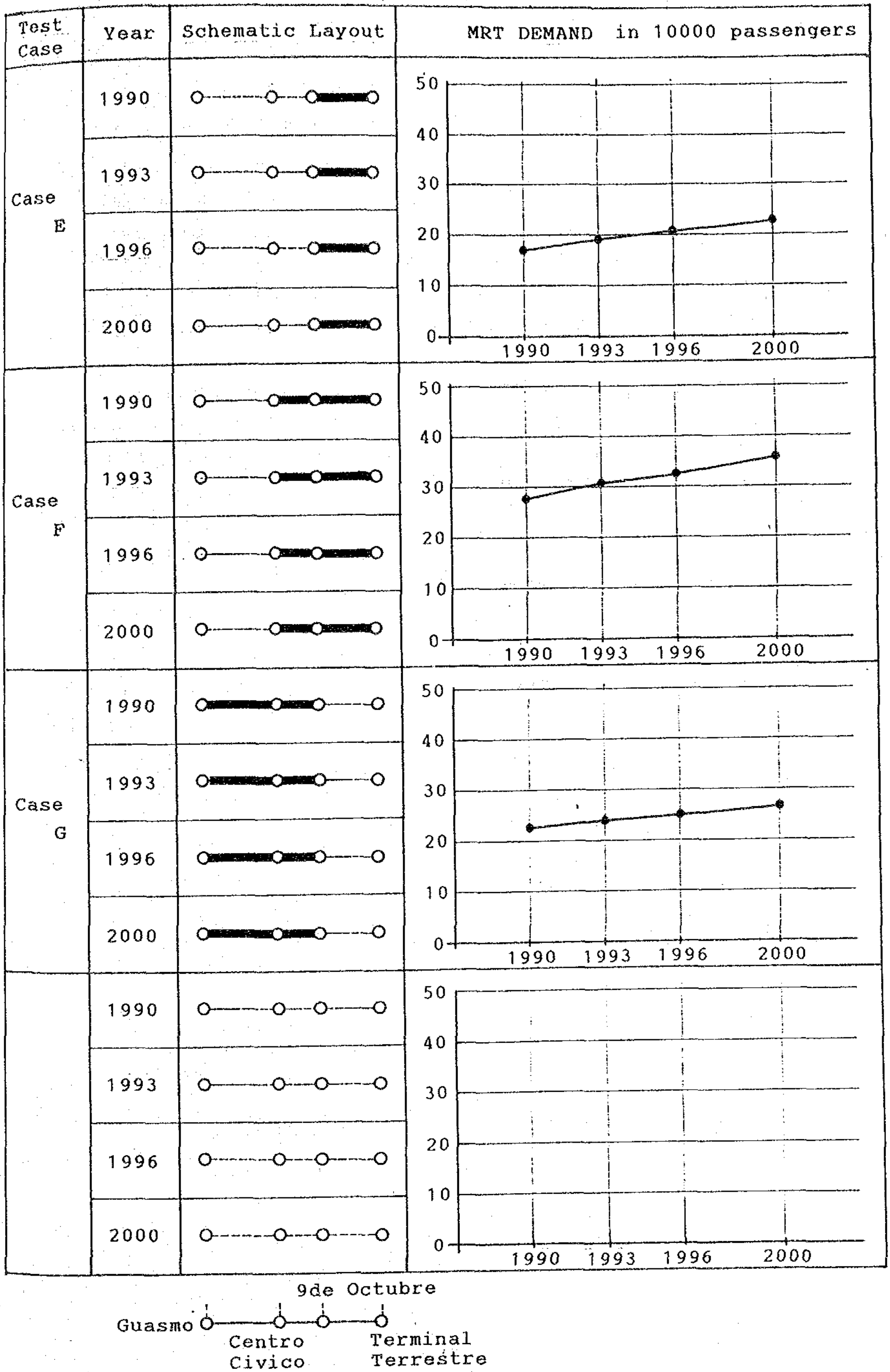


Figure 4-4.1(2) MRT DEMAND FORECAST BY TEST CASE (2)



4-5 Demand Changes Diverted to MRT by Fare Level

It is conceivable that a change in the MRT fare level influences either an increase or decrease in the MRT demand. The change in the demand is examined by using a forecasting model when the MRT fare level varies to the various levels.

The result of the examination is expressed with the fare-demand-curve as shown in Figure 4-5.1. The basic Case in 1990 was used for trial calculation.

According to this fare-demand-curve, it is possible to estimate that an increase by 5 Sucre in the fare level decreases 40,000 to 50,000 persons in the volume of passengers or 10 to 13% in the rate of demand.

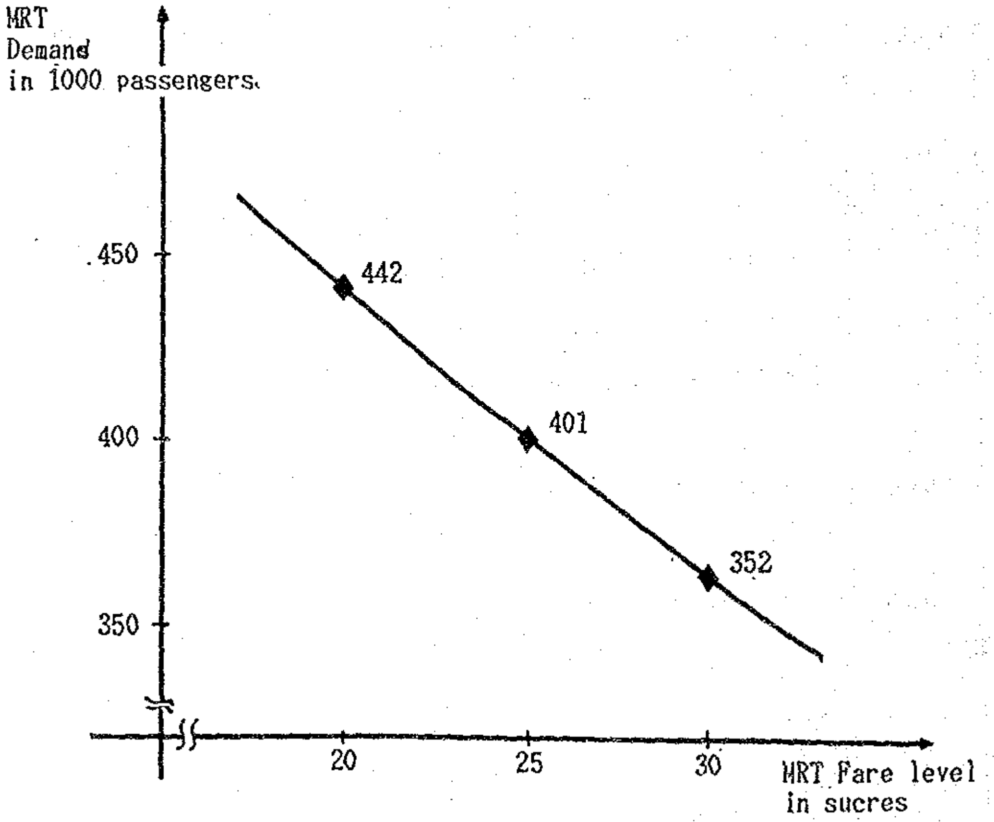


Figure 4-5.1 MRT DEMAND CHANGES BY MRT FARE LEVEL

Note) The curve is obtained statistically based on the estimation of demand.

4-6 Demand Forecast with and without Bus Route Reorganization

It is conceivable that the bus route reorganization is the most influential factor on the MRT demand estimation because the diversion from the bus to the MRT can be enhanced directly as a result of changing and abolishing the bus routes which overlap with the MRT route, and making passengers' transfer convenient by providing transfer facilities between the MRT and the bus.

Calculation for comparison of with- and without-bus route reorganization was conducted first by eliminating consideration on the bus route reorganization described in 4-1 from the forecasting model and second by carrying out simulations under such a condition that complete competition has generated between the bus systems and the MRT.

The results of the comparative calculation are as shown in Table 4-6.1 from which is possible to evaluate that the effect of the bus route reorganization has appeared as an increase in the MRT demand by about 89,000 person/day for the Basic Case (the whole route).

Table 4-6.1 DEMAND CHANGE BETWEEN WITH AND WITHOUT BUS ROUTE REORGANIZATION

Category of diversion	Basic Case with bus route re-organization	Basic Case without bus route re-organization	Remarks
From Bus to MRT	363,900	274,800	including demand from Bus Terminal
From Car to MRT	3,800	3,800	
From Taxi to MRT	33,300	33,300	
Total	401,000	311,900	

Note) Estimation in 1990

5. Formulation of Origin – Destination (O–D) Table between Stations

1) Origin-destination (O-D) Table between Stations

The MRT demand which was estimated by the trip diversion model, is subsequently distributed to the MRT network to get the Origin-Destination (O-D) table between stations. The distribution is made by assigning a trip from a zone to its appropriate station determined by a shortest approach distance. The results are shown in Appendix 3-5.

2) Daily Passengers Flow between Stations

Based on the O-D table, the daily passengers flow is also calculated between stations and shown in Table 5-1.1 and Figures 5-1.1.

3) Peak Hour Passengers Flow between Stations

Peak hour passengers flow is calculated simultaneously, applying the peak hour rate to daily passengers flow. The peak hour rate is assumed 12%/one way a day, slightly higher than the actual rate described in the PART 1, so as to afford unforeseeble demand concentration.

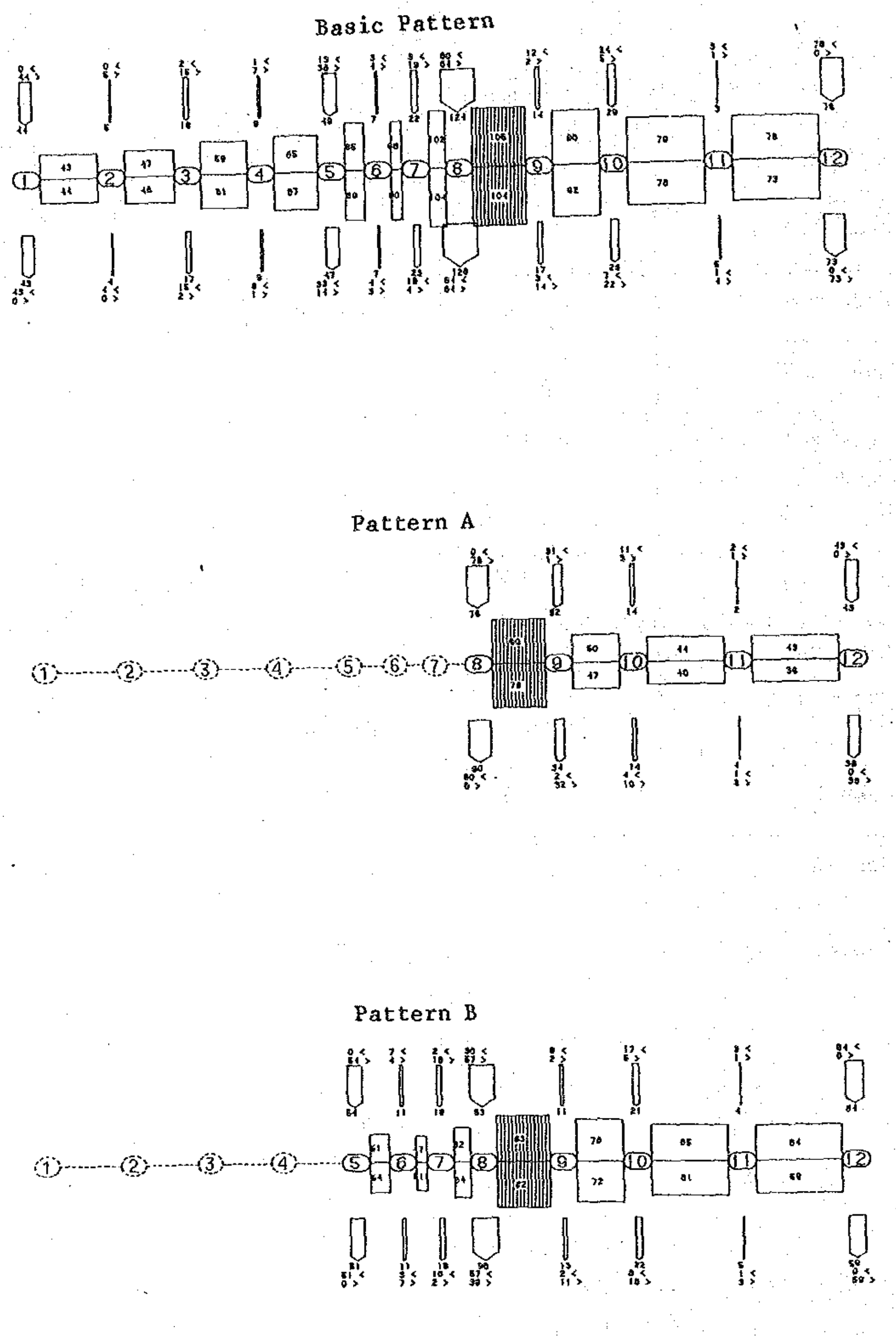
The result is shown in Table 5-1.2.

Table 5-1.1 DAILY PASSENGERS FLOW BY TEST CASE AND YEAR

Unit: Passengers/ day-oneway

Test Case	Passengers Volume			
	1990	1993	1996	2000
Basic Case	105,000	120,800	130,800	145,000
Case A-1	80,000	120,800	130,800	145,000
Case A-2	80,000	94,200	130,800	145,000
Case B-1	82,500	120,800	130,800	145,000
Case C-1	45,000	120,800	130,800	145,000
Case C-2	45,000	92,500	130,800	145,000
Case D-1	88,300	120,800	130,800	145,000
Case E	80,000	87,500	93,300	100,000
Case F	83,500	94,200	102,500	112,500
Case G	88,300	92,500	95,800	99,200

(Note) Figures show largest section volume.



LEGEND

UNIT : 1000 Passengers/day

South bound Trip flow — Boarding passengers

< South bound related

> North bound related

North bound Trip flow — Alighting passengers

(Note) Volume as of 1990

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Figure 5-1.1

MRT PASSENGERS VOLUME BETWEEN STATIONS (SECTIONS)

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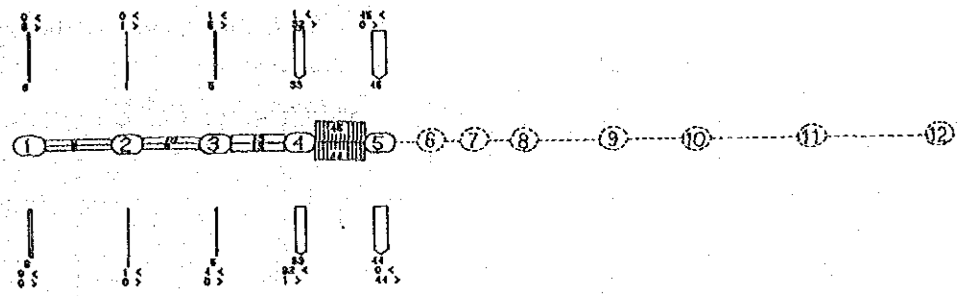
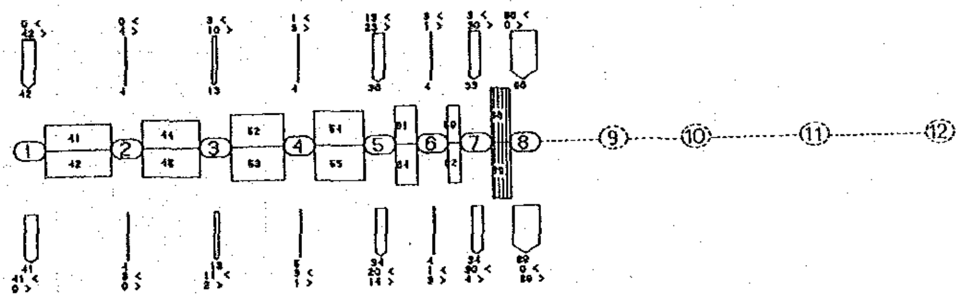
Pattern C



Pattern D



LEGEND

UNIT : 1000 Passengers/day

South bound Trip flow

North bound Trip flow

Boarding passengers

< South bound related

> North bound related

Alighting passengers

(Note) Volume as of 1990

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Figure 5-1.1 (Cont'd)
MRT PASSENGERS VOLUME BETWEEN STATIONS (SECTIONS)

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Table 5-1.2 LARGEST PEAK HOUR PASSENGERS VOLUME BETWEEN STATIONS

Unit: Passengers/ hour--oneway

Test Case	Peak Hour Passengers Volume			
	1990	1993	1996	2000
Basic Case	12,600	14,500	15,700	17,400
Case A-1	9,600	14,500 (10,500)	15,700	17,400
Case A-2	9,600	11,300 (10,500)	15,700 (12,300)	17,400
Case B-1	9,900	14,500 (11,300)	15,700	17,400
Case C-1	5,400	14,500 (5,800)	15,700	17,400
Case C-2	5,400	11,100 (5,800)	15,700 (11,500)	17,400
Case D-1	10,600	14,500 (11,100)	15,700	17,400
Case E	9,600	10,500	11,200	12,000
Case F	9,900	11,300	12,300	13,500
Case G	10,600	11,100	11,500	11,900

Note) The number in brackets shows the peak hour passengers volume just before route extension.

4) Average Passengers Density

The average passengers density gives the general scale of transportation demand size.

It is calculated by following formula.

Average passengers density

$$= \frac{\text{Passengers volume (persons/day)} \times \text{Travel distance (km)}}{\text{Total route length (km)}}$$

Its results by section pattern are shown in Table 5-1.3.

Table 5-1.3 AVERAGE PASSENGERS DENSITY

Section Pattern	Total Route Length(km)	Passengers ·Kilometerage (Persons·km/day)	Average Passengers Density (Persons/day·km)
Basic Pattern	14.7	2,192,895	149,176
Pattern A	6.7	686,159	102,411
Pattern B	9.1	1,185,014	130,221
Pattern C	5.6	202,338	36,132
Pattern D	8.0	865,462	108,183

(Note) Figures are as of 1990.

6. Verification of MRT Demand Based on Influential Area of Stations

In this section, the MRT demand which has already been estimated by the forecasting model is verified from a different method. Verification is carried out by means of comparing the population in an influential area (the range within a 750-meter radius from a MRT station) with a referential value obtained by multiplying the population by the average trip generation and attraction ratio per each person of the population.

The present population along the MRT is shown in Figure 6-1.1. Each number obtained from the census in 1982 shows the population inhabiting within each influential area of a station and the calculated number amount to 256,000 persons in total.

Figure 6-1.2 shows the number of persons to be accommodated in large facilities which exist inside an influential area and generally attract trips. The number is calculated to be 252,000 persons. The largest number for Station 9 is the one for the soccer studium and the Guayaquil University.

Average trip generation and attraction made by a person is calculated in each zone from the present bus O-D table and it is shown in Appendix 3-7. It is used for calculating the MRT demand based on the influential area of stations and its result is shown in Table 6-1.1. This number is a result of having counted the same bus passengers getting on and off in the influential areas and a half of the number is interpreted as the volume of daily passengers of the MRT.

The above volume accounts for about 410,000 passengers a day and it is very consistent with 401,000 passengers a day which was the result of the MRT demand forecast in the Basic Case in 1990.

Judging from this comparison, the following matters are conceivable:

(1) The both numbers are almost same, indicating that the forecastig model was proved to be very appropriate by influential area method.

Note) Circles show the area within 750m of MRT station

Source) National Census (1982)

LEGEND

60,000

40,000

20,000

10,000

unit : persons

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Figure 6-1.1
POPULATION SURROUNDING MRT STATION (PRESENT)

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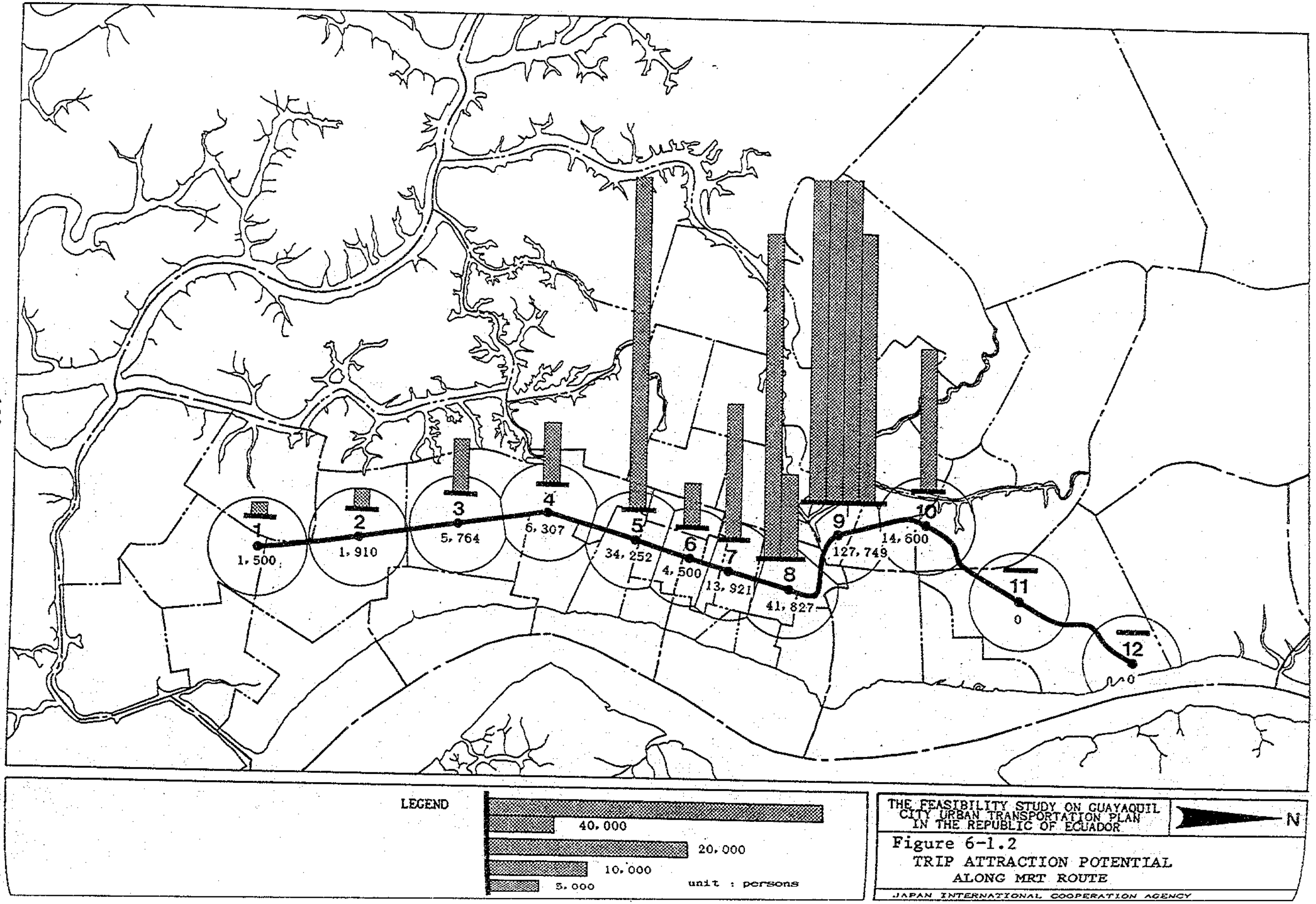

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Figure 6-1.2
TRIP ATTRACTION POTENTIAL
ALONG MRT ROUTE

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(2) According to this result, it seems that the calculation was conducted on such a basis as if all bus trips within the influential areas had diverted to the MRT and then it may be taken for an overestimate in a sense. However, this is an acceptable value from the viewpoint that there is no inclusion of diversion from taxi and cars in this calculation and that Bus Terminal, which is the biggest generating source of demand, is excluded.

(3) Moreover, it is reasonable that the potential of trip generation is fairly high since, in wayside of the MRT, there are a number of large establishments which become the generating and absorbing sources of the traffic flow as already described.

(4) Although only the walking area (within a 750-meter radius from a station) was picked up for the trip calculation, there is a room for expansion of the trip diversion area if connection between the bus and the MRT is improved by the bus route reorganization. Therefore, it is sufficiently possible to materialize the forecast value.

Table 6-1.1 NUMBER OF BUS PASSENGERS FOR MRT DEMAND ESTIMATION IN INFLUENTIAL AREA OF STATIONS

No.	(1 1985 population	Zone	(2 Rate	1990(3 Growth rate	(4 1990 population	Bus trip(5 Generation rate	Bus trip(6 estimation (1990)
1	18,364	501	0.3	1.28	23,000	0.84	19,300
		502	0.4	1.19			
		504	0.3	1.31			
		*		1.25		0.84	
2	8,607	404	0.5	1.18	11,000	1.54	13,100
		501	0.5	1.28		0.84	
		*		1.23		1.19	
3	18,297	402	0.5	1.02	19,000	1.54	29,300
		403	0.5	1.02			
		*		1.02		1.54	
4	33,742	205	0.25	1.08	35,000	1.86	60,600
		206	0.35	0.97			
		402	0.25	1.02			
		403	0.25	1.02		1.54	
		*		1.02		1.73	
5	45,561	201	0.04	1.00	45,000	1.86	83,700
		202	0.20	0.97			
		203	0.10	0.96			
		204	0.50	1.01			
		205	0.01	1.08			
		206	0.15	0.97			
		*		0.99		1.86	
6	26,352	106	0.1	0.92	25,000	5.9	87,000
		107	0.3	0.92			
		201	0.1	1.00		1.86	
		202	0.3	0.97			
		203	0.2	0.96			
		*		0.95		3.48	
7	32,424	101	0.05	0.93	30,000	5.9	177,000
		102	0.05	1.83			
		103	0.3	0.85			
		107	0.25	0.92			
		108	0.3	0.97			
		106	0.05	0.92			
		*		0.91		5.9	
8	55,182	101	0.1	0.93	53,000	5.9	312,700
		104	0.2	0.91			
		105	0.2	1.08			
		109	0.5	0.94			
		*		0.96		5.9	
9	9,928	109	0.15	0.94	9,900	5.9	20,700
		701	0.3	1.00		1.46	
		712	0.2	1.00			
		713	0.2	1.02			
		301	0.15	0.99		1.22	
		*		1.00		2.09	

Table 6-1.1 NUMBER OF BUS PASSENGERS FOR MRT DEMAND ESTIMATION IN INFLUENTIAL AREA OF STATIONS (Cont'd)

No.	1985 population (1	Zone	Rate (2	1990 Growth rate (3	1990 population (4	Bus trip Generation rate (5	Bus trip estimation (1990) (6
10	6,998	702	0.08	1.01	10,000	1.46	14,600
		711	0.07	1.00			
		712	0.15	1.00			
		713	0.2	1.02			
		714	0.5	1.85			
		*		1.43		1.46	
11	83	802	1.0	5.00	400	1.08	400
		*				1.08	
12	270	802	1.0	5.00	1,400	1.08	1,500
		*				1.08	
Total	255,808				262,700		819,900

Note 1) Estimation based on the National Census in 1982 by INEC

2) Zone proportion in infuential area of MRT station

3) Zone population growth rate by the population framework

4) Estimation by average growth rate × 1985 population

5) Bus trip generation and attraction per population

6) (4) × (5)

PART 4

ALTERNATIVES OF MRT ROUTE AND SYSTEM, AND THEIR EVALUATION

PART 4 ALTERNATIVES OF MRT ROUTE AND SYSTEM, AND THEIR EVALUATION

1. Formation of Route Alternatives

1-1 Items to be Considered in Selecting Alternatives

Many projects and plannings have been carried out in Guayaquil since the M/P Study in 1982. They are road widening, intersection improvement (construction of overpass), Terminal Terrestre, big interchange plans, urban development, etc. of which major changes along the MRT route in the M/P Study are shown in Figure 1-1.1.

Taking into account the abovementioned changes of the situation since 1982, sufficient consideration should be given to formation of the alternative routes.

The main items to be considered in selecting the alternative routes are as follows:

(1) Coordination with the intersections under construction, big interchange plans and other road improvement plans

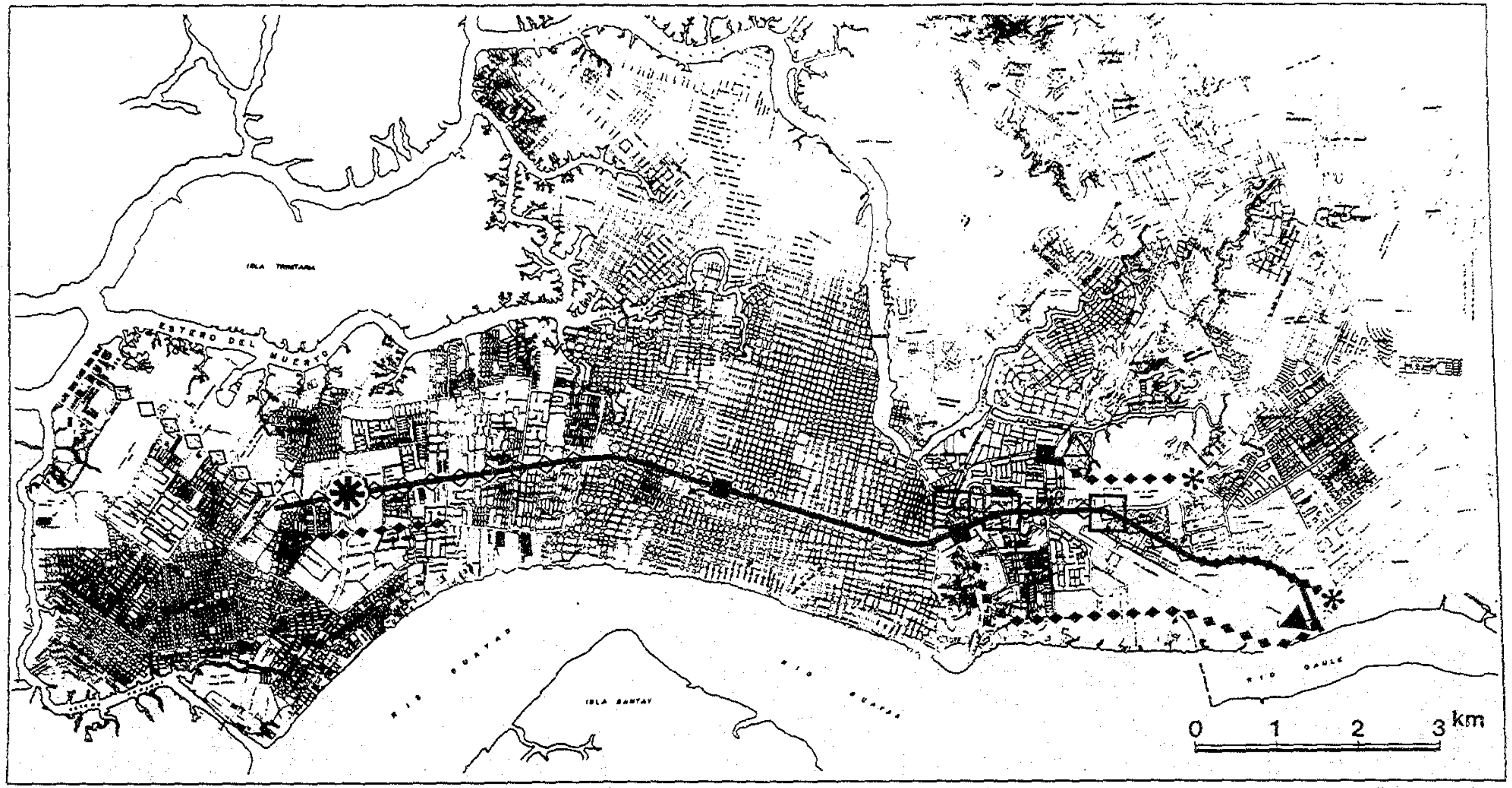
(2) Avoidance of urban establishments and buildings

(3) Possibility of land acquisition and/or reservation

(4) Limitation to the structural height around the airport (The height of structures in and around Circulo Banderas should be equal to the ground level because it is situated exactly on the straight line of the runway in the airport).

(5) Avoidance of underground and aerial obstacles (major obstacles are sewerage pipes with 1.5 m diameter in the center of Av. 25 de Julio, water supply pipes with 1.5 m diameter in Av. San Jorge, electrical cables with 63 kV crossing on Av. Quito.).

(6) Coordination between the bus transport system and the MRT stations



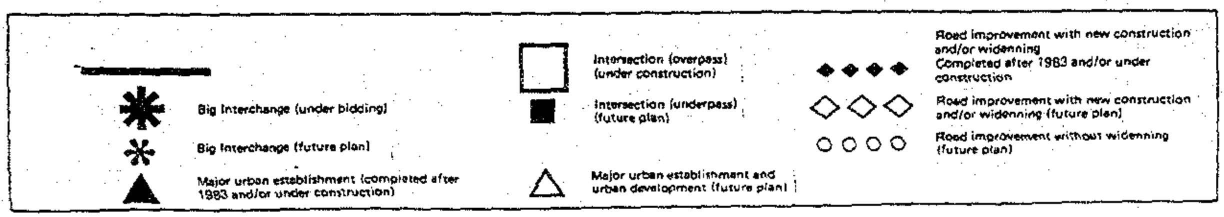


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Figure 1-1.1 CHANGES OF SITUATION ALONG THE MRT ROUTE AFTER 1983

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1-2 Setting of Alternative Routes

1) Candidates of Alternative Routes and Their Characteristics

Taking the abovementioned items into consideration, the candidates of alternative routes are shown in Figures 1-2.1 and 1-2.2. There are no alternative in Av. Quito because of absence of wide road necessary for the MRT except Av. Quito.

The characteristics of each candidate categorized into 3 major factors are shown in Tables 1-2.1, 1-2.2 and 1-2.3. In order to comprehend their characteristics more clearly, the outline of their profiles are shown in Figures 1-2.3 and 1-2.4.

2) Combination of Candidates of Alternative Routes

For the candidates in the northern part of the route shown in Figure 1-2.2, it is possible to combine them each other. All possible combination thereof are shown in Table 1-2.4.

3) Setting of Alternative Routes

a. Southern Part of Route

Since there are only 2 plans as alternatives in the southern part of the MRT route as shown in Figure 1-2.1, these plans are adopted as alternatives to be evaluated by comparison.

b. Northern Part of MRT Route

There are 10 plans possible as alternatives in the northern part of the MRT route including slightly modified ones such as shown in Figure 1-2.2 and the number of plans made by combination thereof amounts to so many as 40. In order to push forward this study effectively and also efficiently, it is better to select profitable combinations of these plans by evaluating roughly the characteristics of each candidate, and the results of the evaluation are as follows:

(1) Part A (Section between Terminal Terrestre and Circulo

Guayas y Quil, see Figure 1-2.2).
All candidates other than Alternative 1 (Alt. 1) are excluded from the object of comparison with the following reasons:

① It is possible to use the airport site.

② Since there is a great freedom for Alt. 1 in selecting its structural form (adopting on-the-ground type in a part, rigid frame structure, small span structure, etc.) owing to the above reason, it is possible in Alt. 1 to decrease construction cost.

③ Alt. 3-4 and 3-5: Since the spans of the superstructures in these cases become long and the whole superstructures become high at the intersection of the MRT with Av. de las Americas, these alternatives are apparently disadvantageous when compared with Alt. 1. In addition, their alignment is inferior to that of Alt. 1, as well.

④ Alt. 3-6: When compared with Alt. 1, access to the buildings in wayside becomes difficult (it is planned by the airport M/P to develop a commercial area in the wayside.) and the alignment is inferior to Alt. 1.

(2) Part B (Section between Circulo Guayas y Quil and northern end of Av. Quito, see Figure 1-2.2).

Alt. 3-1, 3-2, 3-3 and Alt. 2-2 (in a part) are excluded from the object of comparison with the following reasons:

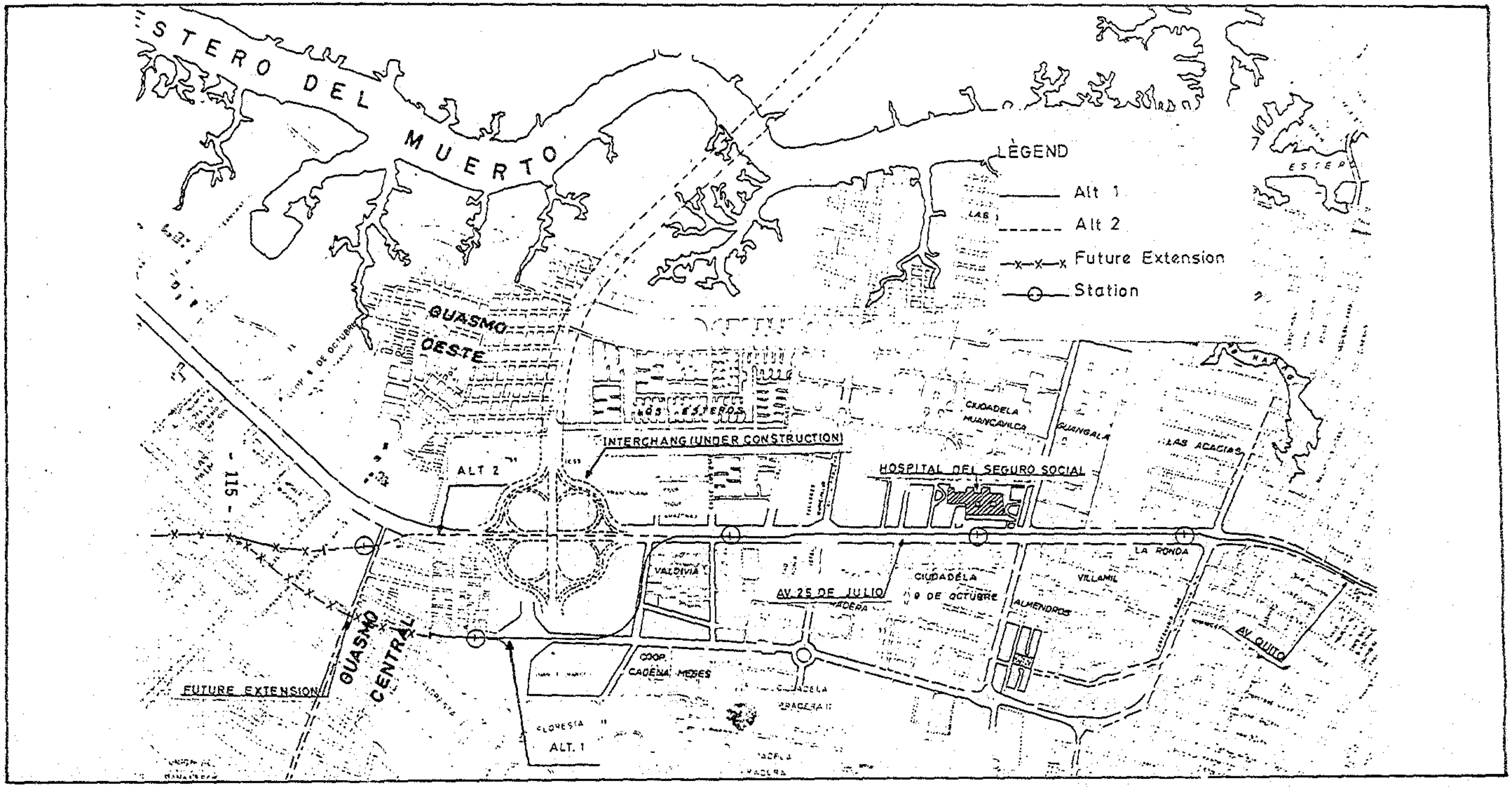
① Alt. 3-1: Since this route intersects with two grade separated crossing roads: one is the present and other is under construction, and also it comes upon large buildings (police station, etc.), it is apparently disadvantageous in terms of the structures' size and land acquisition when compared with Alt. 1.

② Alt. 3-2: Since access to the buildings in the wayside of this route is restricted, it is disadvantageous in terms of land acquisition when compared with Alt. 1.

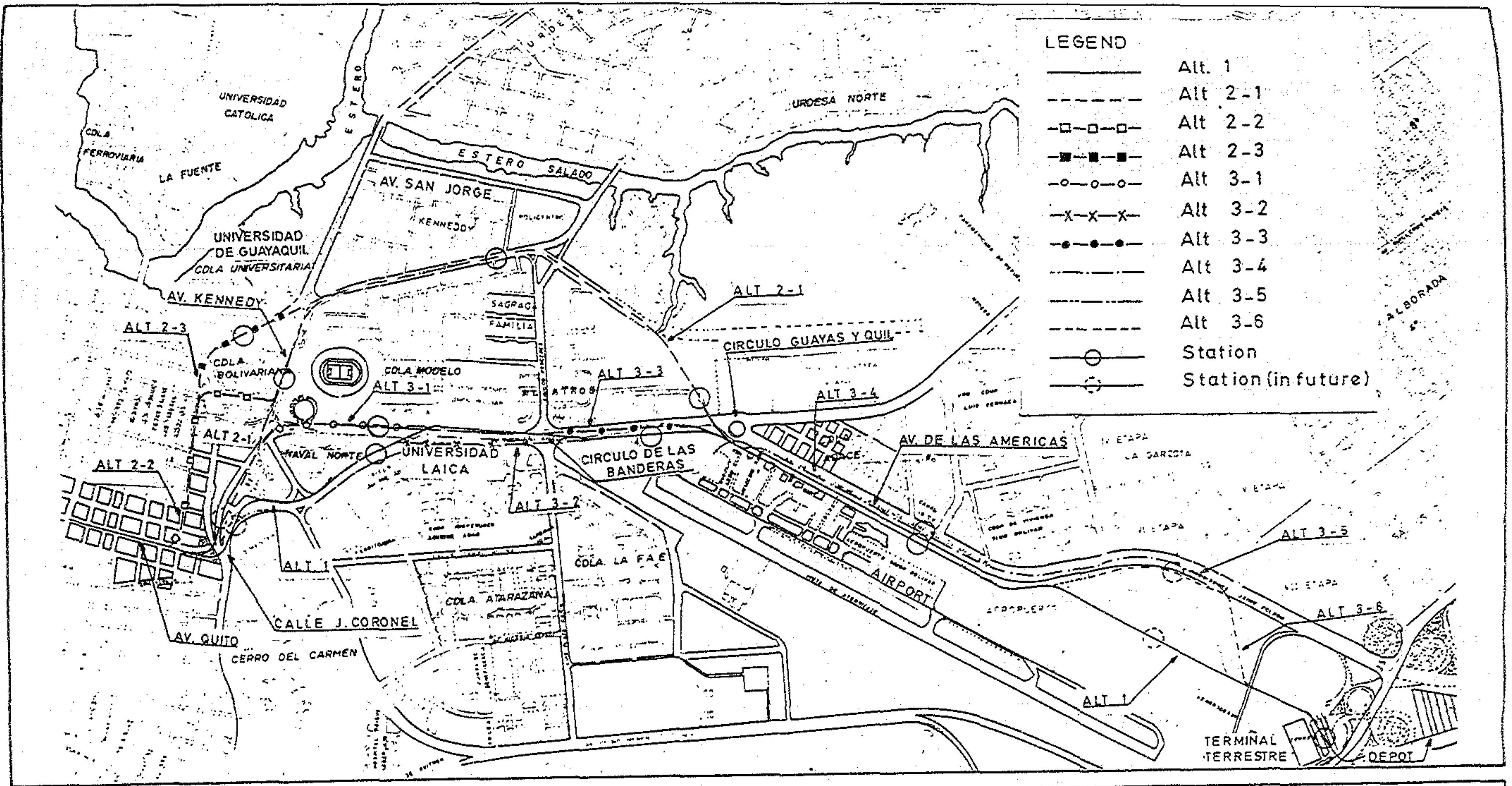
③ Alt. 3-3: This route competes with the improvement plan of AV. de las Américas (The plan is to increase the number of car lanes by making its separator narrower.) In addition, since this route intersects with AV. de las Américas, the profile of the MRT will be bad (Its grade section from the underground to the viaduct has to become long). And also the spans of structures become long. Therefore, this route is also apparently disadvantageous when compared with Alt. 1.

④ Alt. 2-2 (in a part): This route is more disadvantageous than Alt. 2-3 in terms of operation and maintenance of the train since there are 2 sharper curves in this route than the ones in Alt. 2-3 as well as in terms of land acquisition.

From the above evaluation, 3 alternatives shown in Figure 1-2.5 were selected as alternative routes.



THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR	Figure 1-2.1 ALTERNATIVE ROUTES OF THE MRT (SOUTHERN PART)
JAPAN INTERNATIONAL COOPERATION AGENCY	N



THE FEASIBILITY STUDY ON GUAYAQUIL CITY URBAN TRANSPORTATION PLAN IN THE REPUBLIC OF ECUADOR

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Figure 1-2.2 ALTERNATIVE ROUTES OF THE MRT (NORTHERN PART)

Table 1-2.1 CHARACTERISTICS OF EACH ALTERNATIVE (SOUTHERN PART)

Main Factors / Alternative	Land acquisition/reservation	Technical aspects	Construction cost and others
Alt. 1	1. Necessary to expropriate residential area, but land acquisition will be rather easy.	1. Structure will be lower than Alt. 2 2. Alignment is not preferable.	1. Construction cost will be cheaper than Alt. 2
Alt. 2 (see Figure 7-2.1)	1. Same as item 1 of Alt. 1, and area to be expropiated will be less than Alt. 1.	1. The route shall cross over the elevated road in the interchange. 2. Alignment is preferable.	1. Construction cost will be higher than Alt. 1

Table 1-2.2 CHARACTERISTICS OF EACH ALTERNATIVE
(NOTHERN PART A: THE TERMINAL TERRESTRE - CIRCULO GUAYAS Y QUIL)

Main Factors / Alternative	Land acquisition/reservation	Technical aspects	Construction cost and others
Alt. 1	1. Land is owned by CTG, private owner and the airport. Land acquisition/reservation will not be in trouble. 2. If on-the-gound type will be adopted, entrance/exit to the building in the airport will be inconvenient.	1. Possible to adopt on-the-ground type except near Terminal Terrestre and the entrace of the airport. 2. Alignment is good.	1. Possible to decrease construction cost by adopting on-the-ground type.
Alt. 3-6	1. Same as the item 1 of Alt. 1. 2. Same as the item of Alt. 1	1. Possible to adopt on-the-ground type except near Terminal Terrestre. 2. Alignment with many curves is not preferable.	1. Same as the item 1 of Alt. 1 2. As the route is about 200 m longer than Alt. 1, cost is higher than Alt.1
Alt. 3-5	1. As the whole section of the route passes over the road, there is no problem of land acquisition.	1. Necessary to adopt elevated type throughout the whole section of the route. 2. Same as the item 2 of Alt. 3-6.	1. Cost is higher than Alt. 1 and Alt. 3-6
Alt. 3-4	1. Same as the item 1 of Alt. 3-5	1. Same as the item 1 of Alt. 3-5 2. Bridge with large span is required for crossing over Av. de las Américas. 3. High elevated station is required for convenience to connect with the airport terminal.	1. Cost is higher than Alt. 1 · Inconvenient to connect with the airport terminal

Table 1-2.3 (1) CHARACTERISTICS OF EACH ALTERNATIVE
(NORTHERN PART B: CIRCULO GUAYAS y QUIL - AV. QUITO)

Main Factors / Alternative	Land acquisition/reservation	Technical aspects	Construction cost and others
Alt. 1 (Section between Circulo Guayas y Quil and Circulo Banderas) (Corresponds to the section of Alt. 3-3)	1. Whole of this section is located on the airport land. Land acquisition/ reservation will be easy. 2. Necessary to eliminate 2 small buildings	1. MRT structure near Circulo Banderas shall be underground type 2. Possible to adopt on-the-ground type except the above part.	1. Possible to decrease construction cost by adopting on-the-ground type. 2. Connection between the MRT station and bus routes from the north and west is difficult at the station. 3. Overhead pedestrian bridge at the station will be required for crossing Av. de Las Américas.
Alt. 1 (Section between Circulo Banderas and the front of Universidad Laica) (Corresponds to the section of Alt. 3-2)	1. Land owners are mainly public agencies such as Policia Nacional, Colegio Técnico, etc. 2. Necessary to eliminate a small building 3. Entrance/exit to buildings along the route will be inconvenient.	1. MRT structures are composed of both the underground and elevated type. 2. Length of the underground structure is longer than Alt. 3-2.	1. Construction cost will be almost same as Alt. 3-2 (see Alt. 3-2).

(cont'd)

Table 1-2.3 (2)

Main Factors / Alternative	Land acquisition/reservation	Technical aspects	Construction cost and others
Alt. 1 (Section between the front of Universidad Laica and Av.Quito). (Corresponds to the section of Alt.3-1 incl. a part of Alt.2).	1. Land is owned by many private owners. Land acquisition/reservation will not be easy. 2. Necessary to eliminate houses, factories, warehouses, etc.	1. Bridge spans crossing over Calle Julian Coronel will be about 20m to 30m. (Approx. half of Alt.3-1)	1. Construction cost will be cheaper than Alt. 3-1.
Alt. 3-3 (Section between Circulo Guayas y Quil and Circulo Banderas)	1. Most of the route locates over the road. There is no problem in land acquisition. 2. As the separator on the road must be about 10 m wide for the MRT, road widening will have to prepare a future improvement plan.	1. The MRT structures are composed of the underground and elevated type. 2. Profile including the next section is not preferable. It is composed of (viaduct + underground + viaduct). It makes train operation inconvenient.	1. Construction cost is higher than Alt. 1. 2. Same as Item 2 of Alt.I 3. Same as Item 3 of Alt. I Bridge will be higher than Alt. 1.
Alt. 3-2 (Section between Circulo Banderas and the front of Universidad Laica)	1. Land owners are Universidad Laica and privates.	1. The underground structure will be shorter than Alt. 1.	1. Construction cost of structures will be almost same as Alt. 1, but land acquisition cost will be higher than Alt. 1.

(cont'd)

Table 1-2.3 (3)

Main Factors / Alternative	Land acquisition/reservation	Technical aspects	Construction cost and others
Alt. 3-2 (Cont'd)	2. Necessary to eliminate 2 small buildings 3. Entrance/exit to buildings along the route will be inconvenient.	2. In the case of combination with Alt. 3-2 and Alt. 3-3, same as Item 2 of Alt. 1 3. Alignment is not preferable.	
Alt. 3-1 (Section between the front of Universidad Laica and Av.Quito). (A part of this section is in common with Alt. 2-1)	1. Land owners are mainly public agencies. Land acquisition/reservation will be easier than Alt.1	1. Bridge spans crossing over Calle Julian Coronel will be about 40m to 60m and the bridge height will be about 16m. Accordingly, the structures will be larger. 2. Bridges crossing over Av. de las Américas will be same as the above.	1. Construction cost will be higher than Alt.1.
Alt. 2-1 (A part of this route is in common with Alt. 3-1)	1. Most of the route passes on the road. Land acquisition/reservation will be comparatively easy. 2. Necessary to eliminate a big building	1. Same as the item 1 and 2 of Alt. 3-1. 2. Whole of the route will be elevated type.	1. As the route is about 1 km longer than Alt. 1, construction cost will be higher. 2 Connection between the MRT station near Av. de las Américas and bus routes from the north and west will be easy.

(cont'd)

Table 1-2.3(4)

Main Factors / Alternative	Land acquisition/reservation	Technical aspects	Construction cost and others
Alt. 2-2 (Modification of a part of Alt. 2-1 to avoid crossing over the elevated road)	1. Necessary to expropriate residential estate and eliminate some houses.	1. As the route does not cross over the elevated roads, the structure is lower than Alt. 2-1. 2. Alignment with 3 sharp curves is disadvantageous for traino operation and maintenance.	1. Construction cost will be cheaper but operation and maintenance cost will be higher than Alt. 2-1. 2. Protection against environmental destruction will be required for residential area.
Alt. 2-3 (Modification of Alt. 2-2 to avoid sharp curves)	1. Possible to decrease expropriation and elimination rather than Alt. 2-2.	1. Same as the item of Alt. 2-2. 2. Alignment is better than Alt. 2-2.	1. Construction, operation and maintenance costs will be cheaper than Alt. 2-2. 2. Same as the items 2 of Alt. 2-2. 3. Location of a station is not preferable for Estadio, Universidad de Laica, the cemetery, etc.

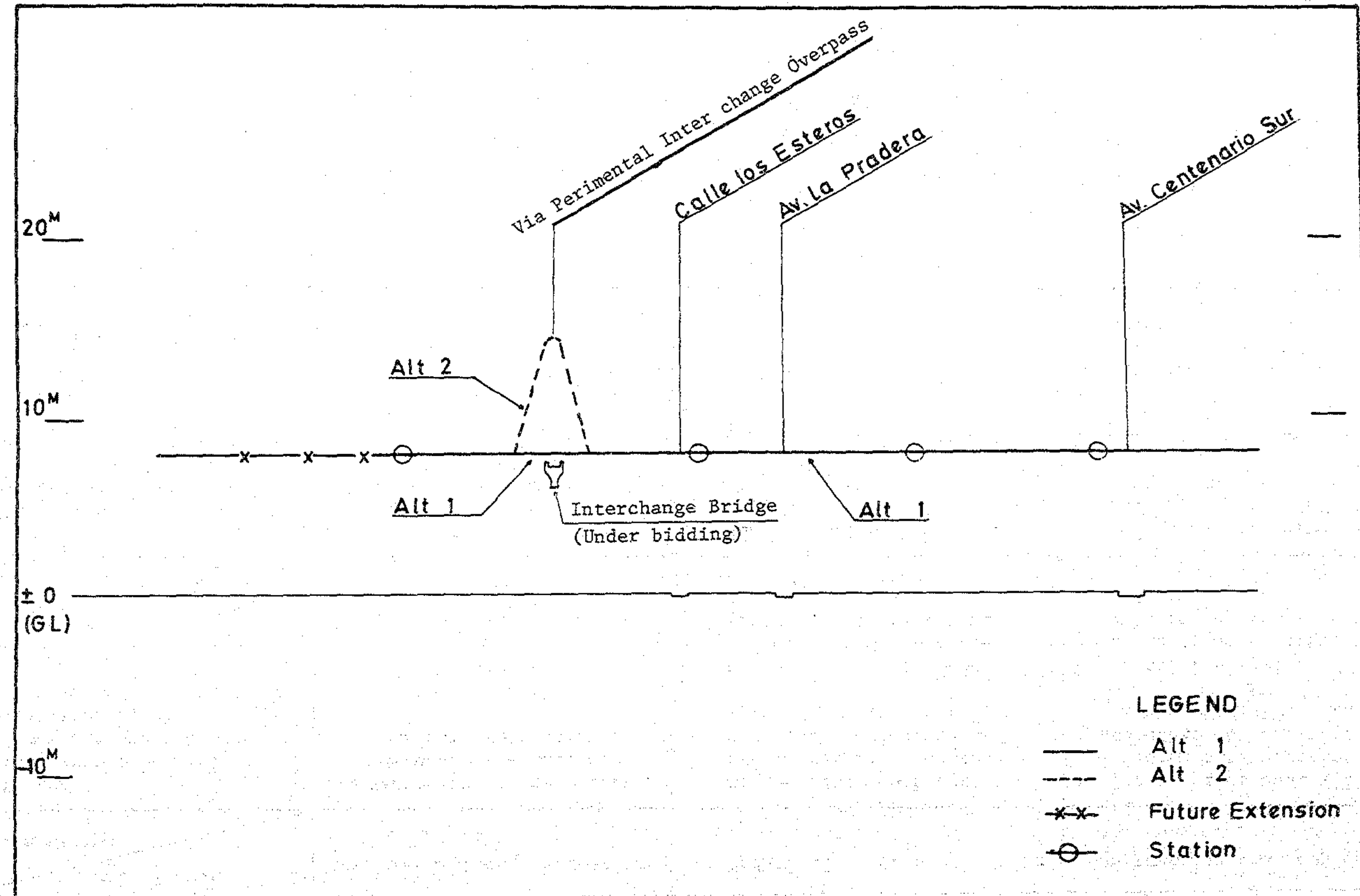


Figure 1-2.3 OUTLINE OF PROFILE OF ALTERNATIVE ROUTES (southern part)

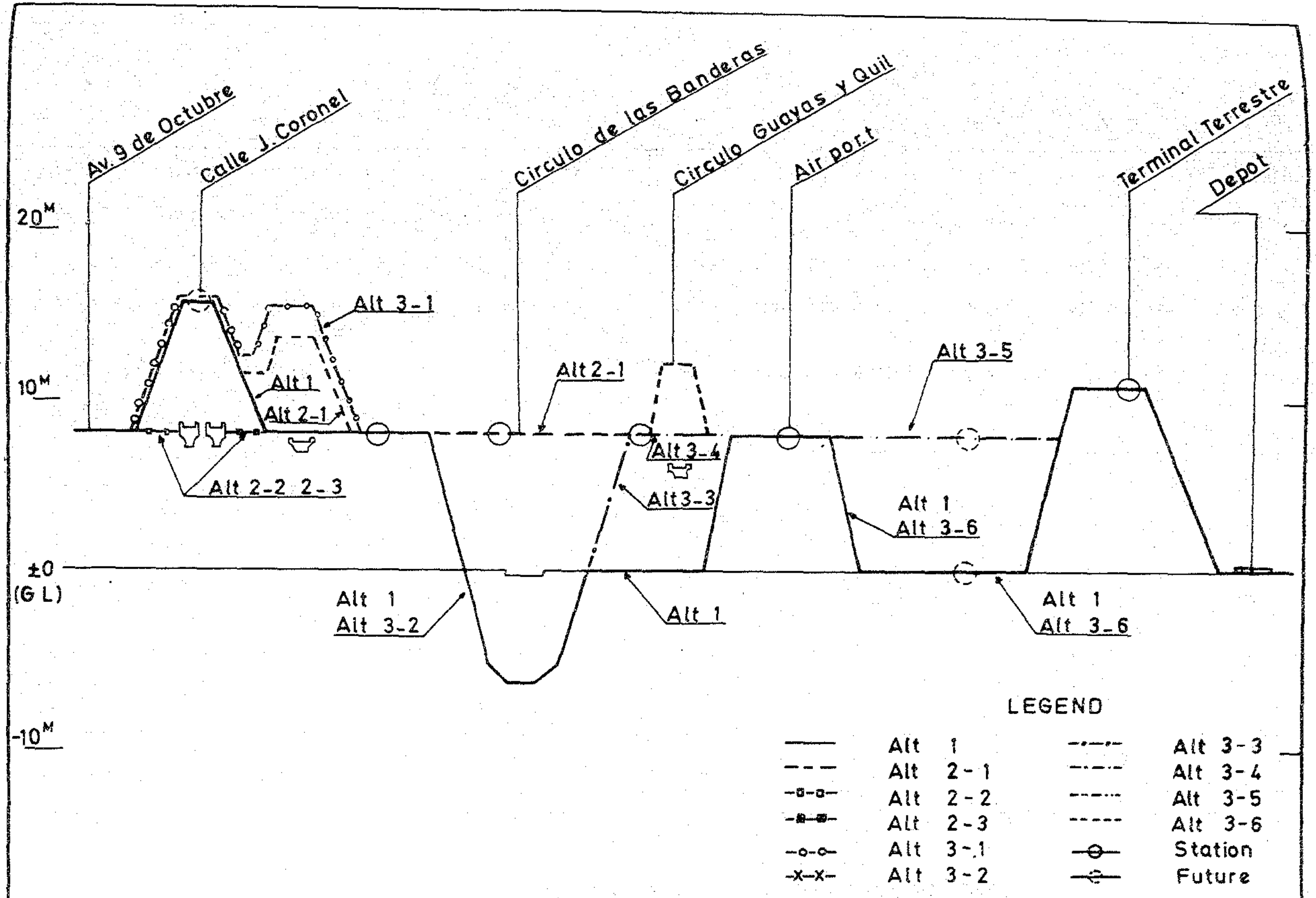
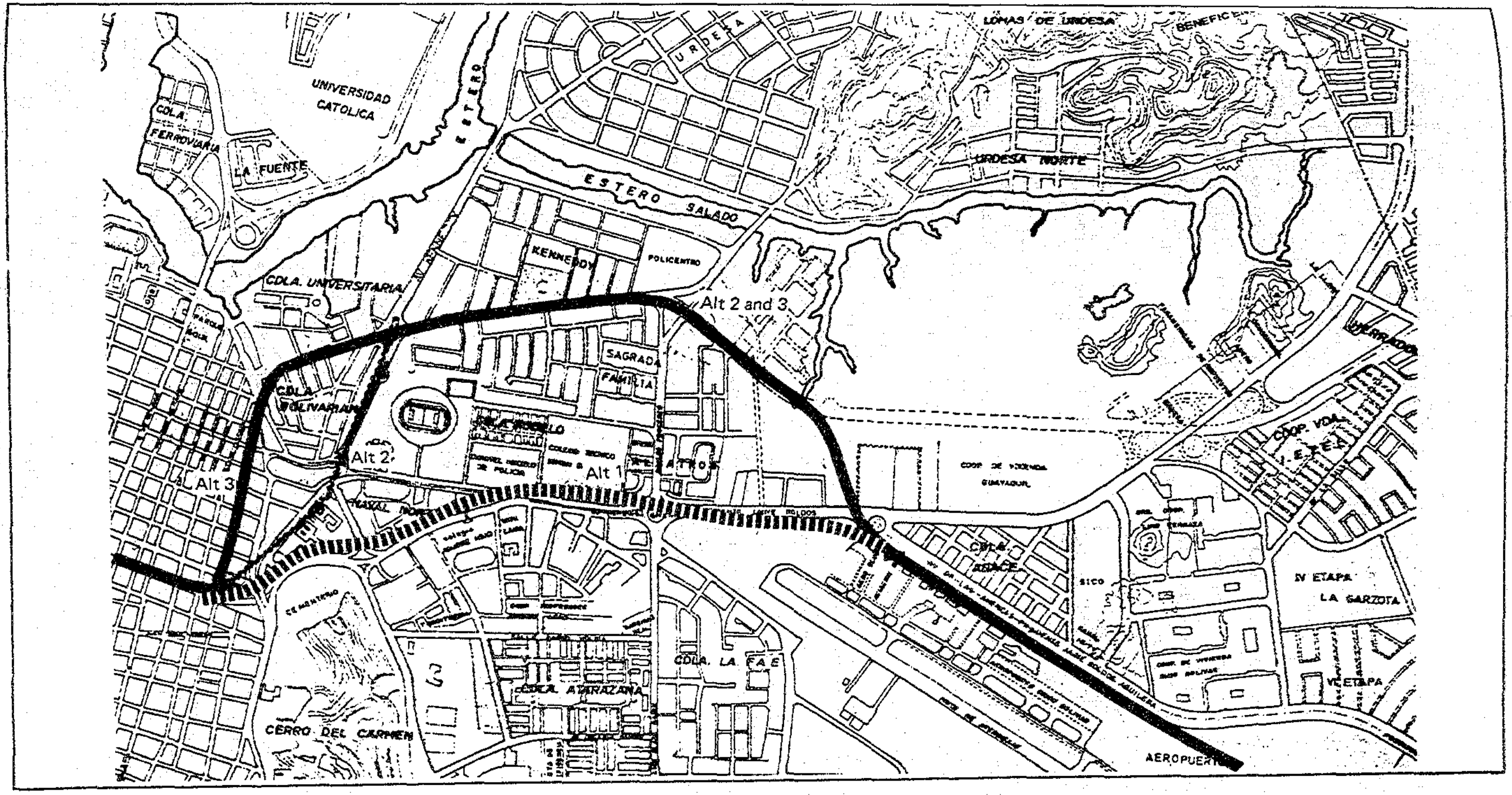


Figure 1-2.4 OUTLINE OF PROFILE OF ALTERNATIVE ROUTES (northern part)

Table 1-2.4 COMBINATION OF CANDIDATES IN NORTHERN PART

Section A (between Terminal Terrestre and Circulo Guayas y Quil)	Section B (between Circulo Guayas Y Quil and Av. Quito)
1. Alt. 1 + Alt. 3-6 + Alt. 1 2. Alt. 1 + Alt. 3-6 + Alt. 1 3. Alt. 1 + Alt. 3-6 + Alt. 3-4 4. Alt. 1 + Alt. 3-6 + Alt. 3-5 + Alt. 3-4 5. Alt. 1 + Alt. 3-4	1. Alt. 1 2. Alt. 1 + Alt. 3-3 + Alt. 1 3. Alt. 1 + Alt. 3-3 + Alt. 1 + Alt. 3-1 4. Alt. 1 + Alt. 3-3 + Alt. 3-2 + Alt. 1 5. Alt. 1 + Alt. 3-2 + Alt. 1 6. Alt. 2-1 7. Alt. 2-1 + Alt. 2-2 8. Alt. 2-1 + Alt. 2-3
(Note) Each combination is composed of sections on the same direction from Terminal Terrestre to Av. Quito. Examples of Combination Case A (All candidates are effective) 5 × 8 = 40 routes Case B (To eliminate Alt. 3-5) 4 × 8 = 32 Case C (To eliminate Alt. 3-4 or 3-6) 2 × 8 = 16 Case D (To eliminate Alt. 3-4 and 3-6) 1 × 8 = 8 Case E (To eliminate Alt. 3-6 and 3-3) 2 × 5 = 10	Case F (To eliminate Alt. 3-6; 3-3, and 3-2) 2 × 4 = 8 Case G (To eliminate Alt. 3-6,3-3,3-2, and 2-3) 2 × 3 = 6 Case H (To eliminate Alt. 3-6, 3-3,3-2,2-3, and 2-2) 2 × 2 = 4



(heavy dashed line)	Alt 1
(thin wavy line)	Alt 2
(heavy solid line)	Alt 3

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Figure 1-2.5

SELECTED ALTERNATIVE ROUTES IN NORTHERN PART

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2. Alternatives of MRT System

2-1 Outline of MRT System

There are many and various kinds of systems in the world but no standardized and/or authorized classification methods have been established yet. Some characteristics of typical systems are shown in Table 2-1.1.

These systems in the above table may cover almost all MRT systems to be examined for this project.

2-2 Items to be Examined for Selecting Alternative Systems

The main items to be examined for selecting the alternative systems are as follows:

(1) Required transport capacity

The required transport capacities in this study are:
12,600 passengers per hour in one direction in 1990
17,400 passengers per hour in one direction in 2000

(2) The investment and operation/maintenance costs are required to be as cheap as possible.

(3) Flexibility for the route requirements

Adaptability to the plane alignment, and profile (sharp curve and steep gradient), etc.

(4) Easy operation and maintenance

(5) Better impacts on the wayside of the MRT

2-3 Selection of Alternative Systems

Table 2-3.1 shows comparison of the MRT systems concerning the adaptability thereof to this project. Judging from this comparison and based on the results of the M/P study, the following 3 systems were selected as the alternatives to be examined more in detail:

- Urban railway (on-the-ground and/or elevated type)
- Light Urban Railway (On-the-ground and/or elevated type with exclusive right of the way)
- Monorail

(Note)

In this report, the LRT (Light Rail Transit) used in the M/P is renamed the Light Urban Railway because although the both systems have same characteristics or performances and are generally classified into a same category, the LRT sometimes means a street railway on roads in joint with car traffic while MRTs in this study are operated only on the exclusive right-of-way through the whole object route of 14.7 km.

The characteristics of the both are that their construction cost is low (about 80% of Urban Railway, if the transport demand is within some region), small occupying space of operating site is enough, and they can be operated on a sharply curved track. So to speak, the Light Urban Railway and LRT are a little small type of the Urban Railway.

Table 2-1.1 CLASSIFICATION OF MRT SYSTEMS WITH MAJOR CHARACTERISTICS

Classification by Rolling Stock Type	Classification by Track Type		Transport Capacity		Comment on Investment Cost
			Conditions for estimation*	Capacity (Person/hour/on way)	
Urban Railway with Steel Tyre	On-the-ground Type Railway Elevated Type Railway		a. 4 cars, = 80m b. 1,680 p/train(300%) c. 3 minutes headway	34,000	In case of subway, its cost will be very expensive.
Rubber Tyre Type Railway	Rubber Tyre Type Railway	Elevated Type Underground Type	a. 4 cars, = 72 m b. 1,200 p/train (250%) c. 3 minutes headway	24,000	Generally, more expensive than the railway with steel tyre
	Monorail (Generally, elevated type will be adopted)		a. 5 cars, = 78 m b. 1,500 p/train (250%) c. 3 minutes headway	30,000	Same as the Rubber tyre Type Railway
	Automated Guideway Transit (Generally, elevated type will be adopted)		a. 10 cars, = 80m b. 900 p/train (120%) c. 3 minutes headway	18,000	ditto
Light Urban Railway	Light Urban Railway (with exclusive right of way)	On-the-ground type Elevated Type	a. 5 cars, =80m b. 1,300 /ptrain (270%) c. 3 minutes headway	26,000	The cost will be almost same as Urban Railway or less in small transport demand
	Tram(without right of way)		a. 1 car, = 26 m b. 390 p/car (250%) c. 3 minutes headway	8,000	Very cheap because of running on existing roads

(Note) * . Conditions for estimation are assumed to be applied to this MRT project.
Items: a, b and c present as follows:

a: Example of rolling stocks in operation, in Japan.

b: Assumed train consist and its length (Train consist of tram shall be made by only 1 car not to interfere road traffic.)

c: Maximum capacity per train is based on examples of the trains operated in Japan.

Table 2-3.1 COMPARISON OF MRT SYSTEMS

		Transport capacity	Investment cost	Adaptability to alignment
Urban Railway	On-the-ground and/or Elevated	o	o	Δ
	Subway	o	×	Δ
Rubber Tyre Type Railway	Elevated Type	o	Δ	o
	Underground Type	o	×	o
	Monorail (Elevated Type)	o	Δ	o
	Automated Guidway Transit (Elevated Type)	Δ (Difficult to cope with trans-port demand increase in future)	Δ (Expensive for large transport demand)	o
Light Urban Railway	On-the-ground and/or Elevated Type	o	o	o
	Tram	×	o	o

NOTE: o Means good; Δ means acceptable; × means unacceptable.

3. Comparison and Evaluation of Alternatives in Route and System

3-1 Comparison and Evaluation of Route Alternatives

1) Outline of Methods

Comparison and evaluation are carried out with the following methods.

(1) The objects of comparison and evaluation are the southern part of of the route (2 alternatives) and the northern part of the route (3 alternatives) separately. In other words, the optimum route as a whole is composed of combination of the optimum ones for the both parts of the route.

(2) In order to evaluate as properly as possible furthermore, evaluation is carried out from various aspects and based on the evaluation ranking categorized into following 3 ranks:

Ranking A: Excellent
Ranking B: Good
Ranking C: Fair

2) Setting of Location of Stations and Depot/Maintenance Shop

It is necessary before the estimation of the project cost for purpose of comparison and evaluation to set the location of the stations and depot/maintenance shop.

The location of the stations is supposed to be as shown in Figure 3-1.1, considering access to principal establishments, connection of the MRT with the bus transport, distance between each 2 stations, etc. The number of stations set in this way is 12 and these stations are classified into the following groups:

- 2 terminal stations (2-stories and located off road)
- 3 main stations (2-stories and located over road)
- 7 standard stations (1 story and located over road for 6 - stations, 1 story and located off road for 1 station)

The position of the depot/maintenance shop is set in the undeveloped open area located in the northward of Terminal Terrestre because there are almost no other sites suited to the facilities.

3) Comparison and Evaluation of Alternatives in Southern Part of Route

The results are shown in Table 3-1.1 Judging from this table, Alt. 2 is selected as the optimum plan.

The reasons of the above selection are surmamarized as follows:

(1) The project cost, which is a very important factor in the route selection, is almost same to the both alternatives.

(2) In comparison with Alt. 1, Alt. 2 has some advantages on another factors, such as appropriateness to connection with bus routes, good alignment of the line, easiness for land acquisition and compensation, etc.

(3) Although Alt. 1 is slightly superior in the profile of the route and easiness for construction work, these advantages seem to be not so significant as the item in the above (2).

<u>Some comments on comparison and evaluation</u>

(1) Construction cost is one of the important factors in selecting the route but, because the distance of the section to be the object of comparison and evaluation is same for the both alternatives and comparatively so short as about 1.7 km, there is no difference of the construction cost between them except the cost of the civil engineering work and the costs of land acquisition/compensation. In addition, the amount of these differences in the cost does not affect significantly the total project cost.

(2) Therefore, comparison and evaluation of the construction cost of the both alternatives were carried out only concerning the total cost of the civil engineering work and land acquisition/compensation of the sections to be compared. As there was almost no difference between the both alternatives as shown in Table 3-1.1 both of them were ranked as A rank.

4) Comparison and Evaluation of Alternatives in Northern Part of Route

The results are shown in Table 3-1.2 Based on this table, Alt. 3 is most recommendable as the optimum plan.

Final ranking shown in the table was decided based on the following considerations:

(1) The project cost of Alt 1 is the cheapest but the difference among them is not so big (it is 4% to Alt 3 and 6% to Alt 2).

(2) On the other hand, transport demand of Alt 2 and 3 is about 10% more than Alt 1.

(3) As for the other items compared, Alt 3 is most advantageous on almost all of them. Especially, it is superior to the others in the profile of the route (ups and downs are few), size of the trackway structures (no necessity of long span and high elevated structures) and easiness in construction.

Some comments on comparison and evaluation

(1) The characteristics of each section of the alternatives in the northern part of the route are as shown in Table 1-2.3. However, as the characteristics of the alternative routes as a whole, there are such relative ones that the difference of the route length among them is so big as 1 km and that the state of wayside varies to a great extent depending on the place through which respective route runs,

the difference of these characteristics influences seriously the construction cost and transport demand.

(2) Because the difference of the route length among the alternatives is so big as about 1 km, comparison of the construction cost was carried out concerning the total project cost for the full length of the object route of this study including the costs of rolling stocks, electrical facilities, etc.

Moreover, although the construction cost varies depending on the MRT system to be applied, an approximate project cost was estimated concerning the 3 MRT systems selected in Section 2-3.

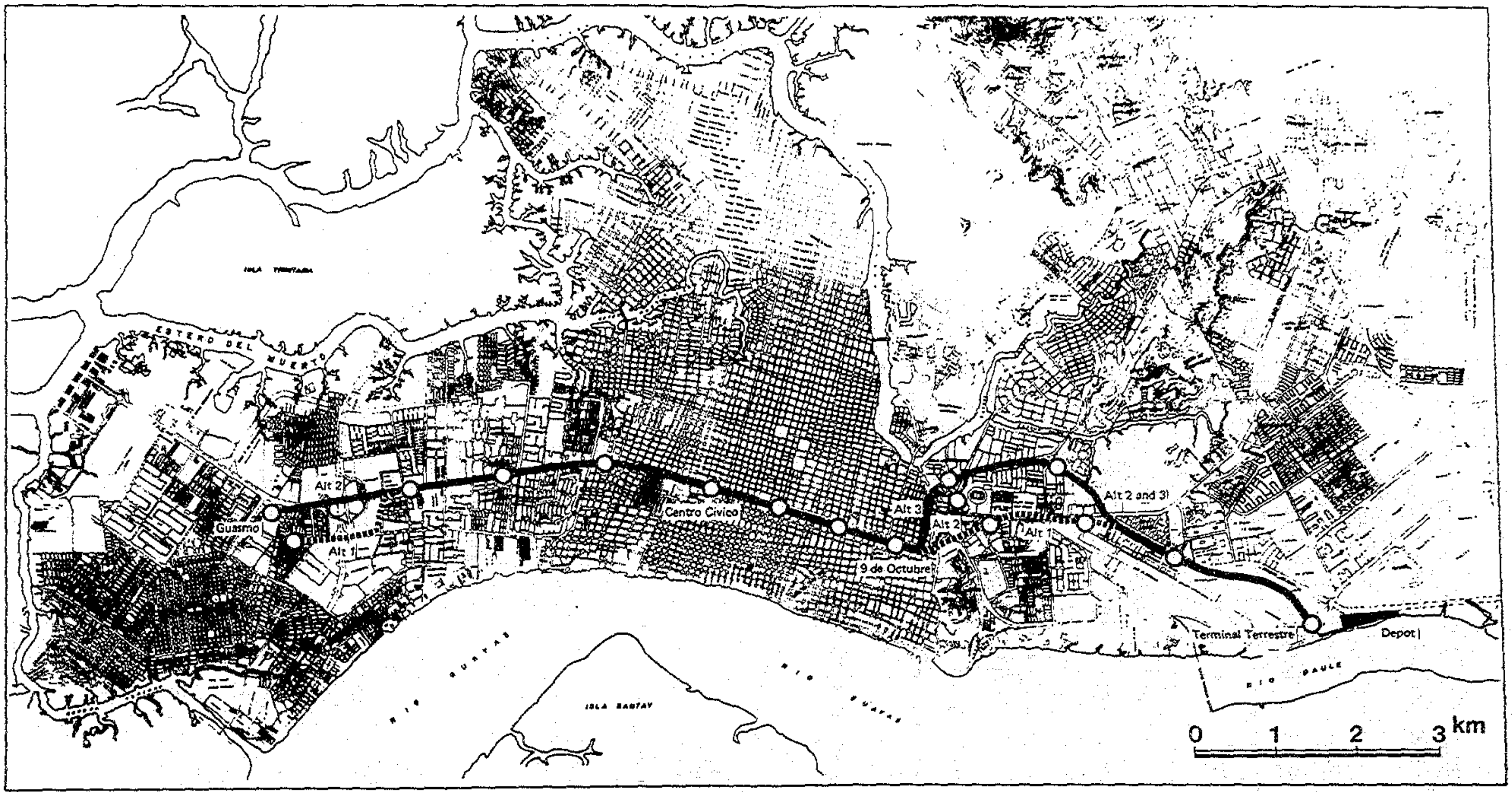
The results of estimation are shown in the table hereunder:
(For the details, refer to Appendix 4-1.)

Approximate Project Cost by Alternative Route and System

(Unit: Million sucres in 1985 prices)

Alternative Route / Alternative System	Alt 1	Alt 2	Alt 3
Urban Railway	29,206 (1.00)	31,133 (1.07)	30,604 (1.0)
Light Urban Railway	27,223 (1.00)	28,876 (1.06)	28,446 (1.04)
Monorail	34,475 (1.00)	35,677 (1.03)	35,280 (1.02)

Note:
- Figures in ( )mean the ratio to Alt 1.
- 1 US dollar = 120 sucres = 210 Japanese Yens as of October, 1985 on the free market base,



Alt 1 in Southern and Northern part

Alt 2 in Northern part

Alt 2 in Southern part, Alt 3 in Northern part and sections without route alternatives

Station

Depot and maintenance shop

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Figure 3-1.1 ROUTE ALTERNATIVES AND LOCATION OF STATIONS AND DEPOT

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Table 3-1.1 COMPARISON AND EVALUATION OF ALTERNATIVE ROUTES IN SOUTHERN PART OF THE ROUTE

Comparison Item \ Alternative Routes		Alt 1		Alt 2	
1. Route length (km)		1.7	-	1.7	-
2. Number of stations		1	-	1	-
3. Transport demand (passengers per day in 1990)		no different from Alt 2	-	no different from Alt 1	-
4. Appropriateness to connection with bus routes		• disadvantageous to connection with the route from Guasmo Oeste • difficult to acquire land for bus terminal	C	• Alt 2 is more advantageous to both points than Alt 1.	A
5. Accessibility to major urban establishments (major establishments and approx. number of their users)		There are no major urban establishments near the objective section.	-	Same as left	-
6. Alignment of the line and profile (incl. track maintenance, operating efficiency)	Alignment	• sharp curves at 2 places • disadvantageous to track maintenance and operating speed	C	• almost straight	B
	Profile	• almost level		• steep gradient (up and down): 1 place	
7. Characteristics of structure of way		• No high elevated structures are required but long-span beams with sharp curve are required to overpass the existing roads.	B	• High elevated structures are required to overpass the planned interchange. (L = 0.4 km Hmax = 12.7 m Hmean = 9.5 m)	C
8. Difficulty and/or easiness for land acquisition and compensation	Land acquisition	• difficult, because of many proprietors (11,000 m^2)	C	• easier than Alt 1, because of few proprietors (5,200 m^2)	A
	Compensation	ditto (10,000 m^2)		ditto (3,000 m^2)	
	Approx. Cost	122 million sucres		40 million sucres	
9. Adaptability to road improvement plans, and/or interference with road traffic		• unnecessary to coordinate with the planned interchange but necessory to coordinate with distributor roads.	A	• necessary to coordinate with the planned interchange	B
10. Impacts to wayside		• necessary to take countermeasures, protecting the environment from turning for the worse, because most of the route passes through residential area	C	Environmental impacts to wayside are little.	A
11. Difficulty and/or easiness for construction work		easy	A	• comparatively difficult to construct the intersection (overpass) of the planned interchange	B

(continue)

Table 3-1.1 COMPARISON AND EVALUATION OF ALTERNATIVE ROUTES IN SOUTHERN PART OF THE ROUTE (Cont'd)

Comparison Item \ Alternative Routes	Alt 1		Alt 2	
12. Project Cost (for 1.7 km of the route) (Unit: million sucres)	Civil work cost 1,439 Land cost 122 Total 1,561	A	Civil work cost 1,515 Land cost 40 Total 1,555	A
Ranking from synthetic judgement	2		1	

(Note) Project cost is estimated in 1985 prices and exchange rate "1US dollar = 120 sucres = 210 Yens"

Table 3-1.2 COMPARISON AND EVALUATION OF ALTERNATIVE ROUTES IN NORTHERN PART OF THE ROUTE

<table>
<tr><th colspan="2">Alternative Routes / Comparison Item</th><th colspan="2">Alt 1</th><th colspan="2">Alt 2</th><th colspan="2">Alt 3</th></tr>
<tr><td colspan="2">1. Route length (km)
(as for whole route length)</td><td colspan="2">3.5 (13.7)</td><td colspan="2">4.5 (14.7)</td><td colspan="2">4.5 (14.7)</td></tr>
<tr><td colspan="2">2. Number of stations
(as for whole route)</td><td colspan="2">2 (12)</td><td colspan="2">2 (12)</td><td colspan="2">2 (12)</td></tr>
<tr><td colspan="2">3. Transport demand
(passengers per day in 1990)</td><td>365,000</td><td>B</td><td>401,000</td><td>A</td><td>401,000</td><td>A</td></tr>
<tr><td colspan="2">4. Appropriate places to connection with bus routes</td><td>None</td><td>C</td><td>1 place near Policentro</td><td>A</td><td>Same as left</td><td>A</td></tr>
<tr><td colspan="2">5. Accessibility to major urban establishments
(major establishments and approx. number of their users)</td><td>Laica University,
Aquirre Highschool,
National Police Station,
Stadium
(Approx. 30,000 persons excl. stadium)</td><td>C</td><td>Guayaquil University
Stadium
Policentro
(Approx. 60,000 persons excl. stadium)</td><td>A</td><td>Same as left</td><td>A</td></tr>
<tr><td rowspan="2">6. Alignment of the line and profile (incl. track maintenance, operating, efficiency</td><td>Alignment</td><td>· Sharp curves (R≦160m):
3 places
· Complex of curves and gradient:
many places</td><td rowspan="2">C</td><td>· Sharp curves (R≦160m):
4 places
· Same as left</td><td rowspan="2">B</td><td>· Sharp curves (R≦160m):
4 places
· Complex of curves and gradient:
few places</td><td rowspan="2">A</td></tr>
<tr><td>Profile</td><td>Ups and downs are many.</td><td>Ups and downs are less than Alt 1 and more than Alt 3.</td><td>Ups and downs are few.</td></tr>
<tr><td rowspan="3">7. Structure Types (Advantages from structural aspects)</td><td>Elevated</td><td>2.3 km
(high elevated: 0.7 km)
(maximum beam span: 40 m)</td><td rowspan="3">C</td><td>4.5 km
(high elevated: 1.0 km)
(maximum beam span: 60 m)</td><td rowspan="3">B</td><td>4.5 km
(high elevated: none)
(maximum beam span: 35 m)</td><td rowspan="3">A</td></tr>
<tr><td>Underground</td><td>0.6 km</td><td>None</td><td>None</td></tr>
<tr><td>On-the-ground</td><td>0.6 km</td><td>ditto</td><td>ditto</td></tr>
<tr><td rowspan="3">8. Difficulty and/or easiness for land acquisition and compensation</td><td>Land acquisition</td><td>Difficult, because of many proprietors (15,000 m²)</td><td rowspan="3">C</td><td>easier than Alt 1, because of few proprietors (14,300 m²)</td><td rowspan="3">A</td><td>Same as left (13,200 m²)</td><td rowspan="3">A</td></tr>
<tr><td>Compensation</td><td>ditto (6,000 m²)</td><td>ditto (2,100 m²)</td><td>ditto (2,760 m²)</td></tr>
<tr><td>Approx. cost</td><td>205 million sucres</td><td>137 million sucres</td><td>136 million sucres</td></tr>
</table>

(Continue)

Comparison Item \ Alternative Routes	Alt 1		Alt 2		Alt 3	
9. Adaptability to road improvement plans, and/or interference with road traffic	• Necessary to Coordinate with the intersection plan (underpass) of Av. Quito and Av. Pedro Menendez	B	no problem	A	Necessary to restrict road traffic flow on Calle M. Galecio	B
10. Impacts on land use of wayside	• Effects on development of wayside is not expected too much. • Exit/entrance to buildings along the route is inconvenient.	C	• Effects on development of wayside are expected.	A	Same as left	A
11. Difficulty and/or easiness for construction work	• difficult to construct the high elevated overpass and underpass heavy traffic road.	C	• difficult to construct the high elevated overpasses	B	Easy	A
12. Project Cost (as for the whole route in case of Light Urban Railway) (unit: million sucres)	27,223 (1.00)	A	28,876 (1.06)	C	28,446 (1.04)	B
Ranking from synthetic judgement	2		3		1	

(Note) 1. Project cost is estimated in 1985 prices and exchange rate: "1US dollar = 120 sucres = 210 Yens."

2. Project costs of other MRT systems are shown in the Table at page 150.

3-2 Comparison and Evaluation of Alternative Systems

1) Outline of Methods

Comparison and evaluation are carried out with the following methods:

(1) The basic specifications are set for the 3 selected alternatives and, based on these specifications, comparison and evaluation are carried out. For the basic specifications, description is given in the following section.

(2) Evaluation of the alternative systems is carried out with the method same as the one used for evaluation of the alternative routes (Refer to 3-1).

2) Setting of Basic Specification

The major characteristics of the 3 alternative systems to be evaluated are outlined in Table 2-1.1 but there are various variations in each alternative system concerning respective transport capacity, performance, etc. Accordingly, in order to make comparison and evaluation clearer, it is required to set the basic specifications of each system. In this way, such specifications are set based on the model of each system shown hereunder:

- Urban railway: Commutation type rapid railway in a large urban sphere. For example, the Yamanote Line of the Japanese National Railways which is the most typical one in Japan.
- Light Urban: Railway — A railway which has made rolling stocks lighter, smaller and more efficient for urban railway recent years. For example, the Ginza Line with 14.3 kilometers which carries about 500 thousand passengers a day operated by

Teito Rapid Transit Authority in Tokyo, Japan.

- Monorail: Commutation type large size monorail in a large urban sphere
For example, the Monorail Kokura Line opened in 1985 in Kitakyushu City, Japan

The basic specifications of these three systems are shown in Table 3-2.1

3) Comparison and Evaluation of Alternative Systems

The results are shown in Table 3-2.2. Based on this table, Light Urban Railway is selected as the optimum system.

The reasons for the above selection are explained hereunder:

(1) As for the project cost, Light Urban Railway is 8% and 24% cheaper than Urban Railway and Monorail, respectively. In this point, Monorail is too expensive in spite of its some advantages on the other items, and Urban Railway is not so expensive as Monorail but it is inferior to Light Urban Railway in the other items: adaptability to route conditions, operation and maintenance cost, flexibility to route selection in future extension, etc.

(2) On the other hand, transport capacity of Light Urban Railway is a little less than Urban Railway. However, it is not so significant as the project cost, because Light Urban Railway has enough capacity for the transport demand in 2000 and it will be possible to cope with demand increase in future.

(3) Resulting from the above, Light Urban Railway ranks first.

Table 3-2.1 BASIC SPECIFICATIONS OF EACH ALTERNATIVE SYSTEM

	Urban Railway	Light Urban Railway	Monorail
1. Basic Models	Yamanote Line of JNR	Ginza Line of Teito Rapid Transit Authority	Monorail Kokura Line
2. Train consist	4 cars	5 cars	5 cars
3. Approx. train length (m)	80	80	78
4. Principal dimensions of rolling stock			
1) Size (length x width height) (mm)	20,000 x 2,870 x 3,940	16,000 x 2,550 x 3,485	15,500 x 2,980 x 3,490
2) . Nominal capacity	140 p/car (560 p/train)	95 p/car (475 p/train)	120 p/car (p/train)
. Maximum capacity (for transport plan)	310 " (1,240 ")	200 " (1,000 ")	260 " (1,350 ")
. When filled to its maximum	420 " (1,680 ")	260 " (1,300 ")	300 " (1,500 ")
3) Tare weight (t)	40	30	27
4) Axle load (t)	16	12	11
5. Basic performance of rolling stock			
1) Maximum speed (km/hr) (km/hr)	100	80	80
2) Acceleration (km/hr/sec)	2.8	3.5	3.5
3) Deceleration (km/hr/sec)	3.0, 3.5 (in emergency)	4.0, 4.5 (in emergency)	4.0, 4.5 (in emergency)
4) Maximum gradient (0/00)	35	35	60
5) Minimum curvature (m)	160	120	100
6. Power supply	DC 1500V simple catenary	Same to the left	DC 1500V conduct rail
7. Train control and signal type	ATS & CTC, on-the-ground signal	Same to the left	ATS & CTC, cab signal
8. Communication facilities	Dispatching telephone Train radio	Same to the left	Same to the left
9. Air conditioner	With cooler	Same to the left	Same to the left
10 Construction Guage (width) (mm)	3,800	3,200	3,870
11. Distance between track centers and track guage (mm)	3,700, 1,435	3,100, 1,435	3,700, -
12. Width of elevated section (Standard) (mm)	8,500	7,300	(Distance between outsides of beams) 5,100

Table 3-2.2 COMPARISON AND EVALUATION OF ALTERNATIVE SYSTEMS

Item \ Alternative System	Urban Railway	Light Urban Railway	Monorail
1. Transport capacity and correspondence to transport demand increase in future	A	B	A
· Maximum capacity for transport plan (Person/hour/one way) (Headway = 3 minutes)	34,000	26,000	30,000
cf. · Headway required for demand in 1990. (12,600 persons/hour/one way)	6 minutes	4.7 minutes	5 minutes
· Headway required for demand in 2000. (17,400 persons/hour/one way)	4.2 minutes	3.4 minutes	3.6 minutes
2. Adaptability to route conditions. (judging from minimum curvature and maximum gradient)	C	B	A
3. Operating efficiency and cost. (judging from acceleration deceleration and power cost)	B	A	B
4. Easiness of maintenance (including maintenance cost)	B	A	C
5. Environmental impacts	C	B	A
· Noise and vibration · Influence to radio wave · Landscape	(C) (C) (C)	(B) (B) (B)	(A) (A) (A)
6. Safety (in case of emergency)	A	A	B
7. Comfortability to passengers	B	B	A
8. Advantages on route extension in future (judging from possibility of level crossing with roads in suburbs, flexibility of route selection, etc.)	B	A	C (Level crossing with roads is impossible.)
9. Project cost (million Sucres) (in case of the selected route) (Refer to section 3-1.4)	B	A	C
	30,604 (1.08)	28,446 (1.00)	35,280 (1.24)
Ranking from synthetic judgement	2	1	3

4. Examination of Possibility of Substitute by Bus Transport for MRT

4-1 Purpose and Method of Examination

1) Purpose of Examination

This study is to examine the feasibility for the MRT project which has been concluded in the M/P study in 1983 that the MRT system would be absolutely necessary for resolving the transport problems of Guayaquil. The purpose of this section is to verify again that this premises should be reasonable by examination of the possibility of substitute by the bus transport for the MRT because the M/P focused mainly on the whole line with 50 km while this study purposes to examine a part (15 km) of them.

2) Method of Examination

The examination is carried out under the following premises:

(1) To assume that the route and demand of a new shuttle bus transport system to be examined are same as those of the MRT

(2) To apply the transport volume (17,400 persons per hour in one direction) in 2,000 along the MRT route.

(3) To assume that the shuttle bus will provide almost same services as the MRT, then the schedule speed of a bus will be 25 km/h which is a little less than 30 km/h of the MRT. Nevertheless, in order to satisfy this condition, it will be necessary to construct a bus exclusive road separately from the existing roads becuase it is impossible to transport such volume without bus exclusive lanes on the existing roads.

(4) To assume that the size of the bus is standard one (about 12 m long and about 2.3 m wide) and its maximum capacity is 90 passengers per car.

4-2 Possibility of Substitute by Bus Transport for MRT

1) Estimation of Facility Scale Required

(1) Number of Car Required (N)

- The number of car required per hour in one direction = transport demand / maximum capacity = 17,400/90 = 193 cars
- Headway (t) = 3600 sec / 193 = 19 sec
- Schedule time (T) = route length /schedule speed = (14.7 / 25) x 3600 = 2116 sec = 35.3 min
- Shuttling time (to) = 60 sec

From the above,

N = (T + to) x 2/t = (2116 + 60) x 2/19 = 229 cars

(2) Structure of Way

From the viewpoints of safety operation and equal interval operation, it is impossible to operate buses with 19 second headway. In case of setting the headway to 30 seconds, 2 bus routes become necessary for transporting the designated demand.

(3) Other Facilities

When compared with the MRT, there is almost no necessity for electrical facilities. In addition, it is possible to make smaller the scale of stations and depot/maintenance shop than those of the MRT.

2) Examination from Aspect of Project Cost

The scale of structure of the bus way with 2 lanes is a little wider than the MRT with a double track. In case of the MRT, the cost of the track structures is approximately 50% of the total project cost. Since it is necessary for the shuttle bus system with the same transport capacity as that of the MRT to construct 2 routes, and the cost of each structure of the way is approximately same as that of the MRT, the project cost of the shuttle bus accounts for almost same as that of the MRT by rough estimation even for the structure of the way only. In case of the costs of the facilities for the bus transport system such as vehicles, stations, depot/maintenance shop, etc. being added to the above cost, the project cost of the bus transport system would conceivably account for about 1.5 times as much as that of the MRT.

3) Examination from Aspect of Operation and Maintenance

Since the transport capacity of bus per car is about 1/11 and schedule speed is about 1.2 times of that of the MRT per train, the number of crew required for the bus transport system accounts for about 13 times as many as that of the MRT. In case of the MRT, the number of crew required is about 1/4 of the total number of staff required. In case of the shuttle bus, therefore, even only the number of crew required accounts for about 3.3 times as many as that of the MRT. In case of the number of staff required for stations, maintenance, etc. being added to the above number, the total number of staff required for the bus is supposed to account for about 4 times as many as that of the MRT.

Since, in case of the MRT, the share of the personnel expenses in the operation and maintenance costs is supposed to be about 20%, only the share of the personnel expenses in the bus accounts for about 80% of the MRT. The costs other than the personnel expenses of the bus are assumed to account for equivalent to or more than those of the MRT (because the number of the buses is quite many). In case of the costs other than the personnel expenses being equal for both of the bus and the MRT, the total cost of the former is 160% of that of the latter. Even in case of the costs other than the personnel expenses of the bus transport system is 1/2 of those of the MRT, the total cost of the former accounts for 120% that of the latter.

4) Examination from Aspect of Route Setting

The greater part of the MRT route is set over the streets with 25 to 30 m wide. It is almost impossible to provide 2 bus routes (each route with 2 lanes) for exclusive use over the same street. Accordingly, it is obliged to construct each bus road separately.

One is possible in stead of the MRT, but it is impossible to find out the other road which will not hinder the present road traffic and to dispense with a large amount of cost for land acquisition and compensation.

5) Conclusion

In the above, examination was carried out concerning the possibility of substituting a bus transport system for the MRT from the aspects of the project cost, operation and maintenance as well as route setting. It may be conceivable, however, that, in any aspect of examination, the bus transport system is considerably disadvantageous and there seems to be extremely small possibility in admitting such substitution as this.