Chapter 10 Traffic Demand Forecast

10.1 Introduction

The future traffic demand was forecast by car trips and public transport trips, because the information on the present trips was surveyed by car owner interviews and bus on board surveys, while the person trip survey was carried out in 1984 study. The 1998 survey did not include the information on pedestrian and two wheelers trips, which normally occupies 30 – 40 % of all the trips, therefore, the trip production rate per person per day or characteristics of trips by car ownership could not be estimated. For these reasons and the difference in accuracy of the two surveys, the forecast models were prepared by car and public transport trips.

The forecast procedure is shown in Fig. 10-1-1.

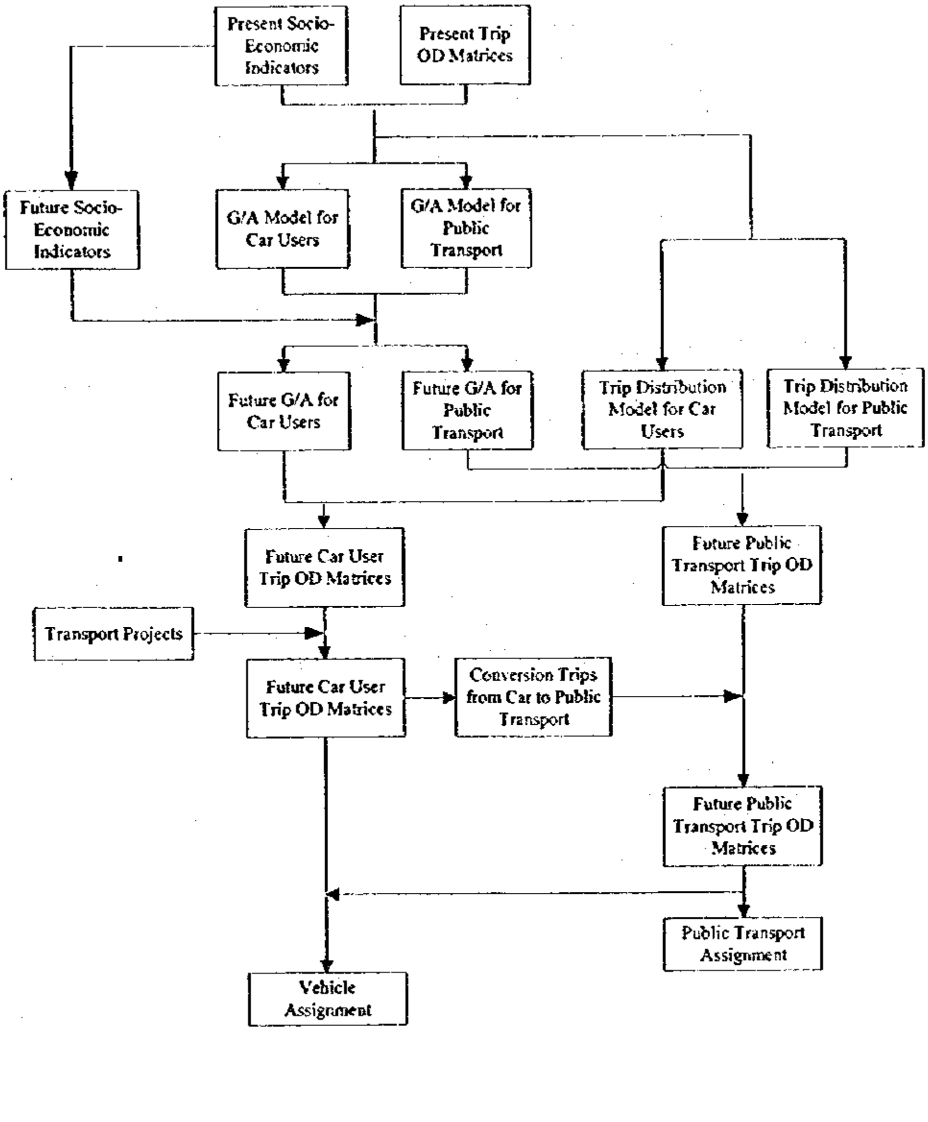

Fig. 10-1-1 Traffic Demand Forecast Process

10.2 Future Trip Generation and Attraction Demand

10.2.1 Trip Generation and Attraction Model

Future trip demand is estimated by modes.
The trip generation and attraction models are expressed by the linear regression equations as follows;

$$Gi = a1\,X1 + a2\,X2 + a3\,D1 + a4\,D2 + a0$$
$$Ai = a1\,X1 + a2\,X2 + a3\,D1 + a4\,D2 + a0$$

Table 10-2-1 Parameters of Trip Generation/Attraction Models

Type of Modes			1st		2nd		3rd		4th		Constant	Co-relation
			Variable	Parameter	Variable	Parameter	Variable	Parameter	Variable	Parameter		
Car	To work	Gen.	V1	0.134	V2	65.300	D1	4,565.36	D2	-2,479.27	-1,007.41	0.948
		Att.	V6	0.892			D3	14,952.99	D4	-7,699.82	-403.08	0.977
	To study	Gen.	V1	0.033	V2	20.252	D5	2,564.08	D6	-1,386.38	-397.09	0.873
		Att.	V4	1.984	V5	0.368	D7	3,755.69	D8	-1,771.67	536.62	0.914
	Related to work	Gen.	V6	0.115			D9	1,307.85	D10	-1,979.62	97.72	0.928
		Att.	V6	0.125			D11	1,192.75	D12	-871.54	25.32	0.970
	Others	Gen.	V1	0.032	V2	20.087	D13	2,285.05	D14	-1,115.64	-178.68	0.881
		Att.	V6	0.264			D15	4,051.63	D16	-2,403.59	89.95	0.946
Bus	To work	Gen.	V1	0.161			d1	9,451.39	d2	-5,270.79	777.91	0.960
		Att.	V6	0.695			d3	8,231.61	d4	-3,399.05	133.82	0.965
	To study	Gen.	V1	0.027			d5	1,664.79	d6	-1,023.78	187.32	0.935
		Att.	V3	0.058	V5	0.280	d7	1,632.41	d8	-1,146.11	284.22	0.916
	Related to work	Gen.	V6	0.065			d9	833.87	d10	-1,485.01	44.91	0.953
		Att.	V6	0.062			d11	526.47	d12	-470.41	49.37	0.954
	Others	Gen.	V1	0.057			d13	5,056.71	d14	-2,308.65	478.81	0.945
		Att.	V6	0.283			d15	3,126.06	d16	-3,085.65	124.51	0.957

V1 *Population*
V2 *Car Ownership (%)*
V3 *Primary-High school students*
V4 *Vocational College students*
V5 *College students*
V6 *Work Place based Employees in Tertiary Sector*
Di,di *Dummy Variables (Dummys with odd number work for under-estimated zone, and dummies with even number work for over-estimated zone)*

The "back home" trips are assumed to be equal to the total of other trips except business trips.

10.2.2 Future Trip Generation and Attraction

(1) Total Trips

Table 10-2-2 shows the total trips from the study area by purpose and by mode in 1998 and in 2015. The total trips of 2,213,000 trips/day in 1998 will increase to 3,922,000 trips/day or 1.77 times, which is larger than the population increase of 1.54 times. The work trips will increase by 1.72 times, school trips 1.39 times, business trips 1.90 times, and other trips 1.67 times.

The share of public transport will decrease from 51.5% in 1998 to 47.5% in 2015, if the same tendency and the same operating condition of the public transport will continue. Therefore, the effect of the improvement of public transport will be discussed in the section on public transport plan as an alternative case.

Table 10-2-2 Total Trips from the Study Area by Purpose and by Mode

	To Work	To Study	Back Home	Related to Work	Others	Total	Share (%)
1998							
Car	365,768	91,817	430,249	65,533	119,198	1,072,565	48.5
Bus	340,550	64,396	556,236	32,590	146,328	1,140,100	51.5
Total	706,318	156,213	986,485	98,123	265,526	2,212,665	100.0
2015							
Car	641,773	130,173	958,292	124,200	204,696	2,059,134	52.5
Bus	572,070	86,530	904,316	61,880	237,998	1,862,794	47.5
Total	1,213,843	216,703	1,862,608	186,080	442,694	3,921,928	100.0
2015/1998							
Car	1.75	1.42	2.23	1.90	1.72	1.92	
Bus	1.68	1.34	1.63	1.90	1.63	1.63	
Total	1.72	1.39	1.89	1.90	1.67	1.77	

(2) Trip Generation/Attraction by Zone

Trip generation/Attraction in 1998 and 2015 by integrated zone is shown in Fig. 10-2-1. The trip generation/Attraction in Micro-Centro will not change so much, however, it will continue to be high, and the trip generation/Attraction in Luque, San Lorenzo, and Ñemby will reach the same level as that of Micro-Centro in 2015.

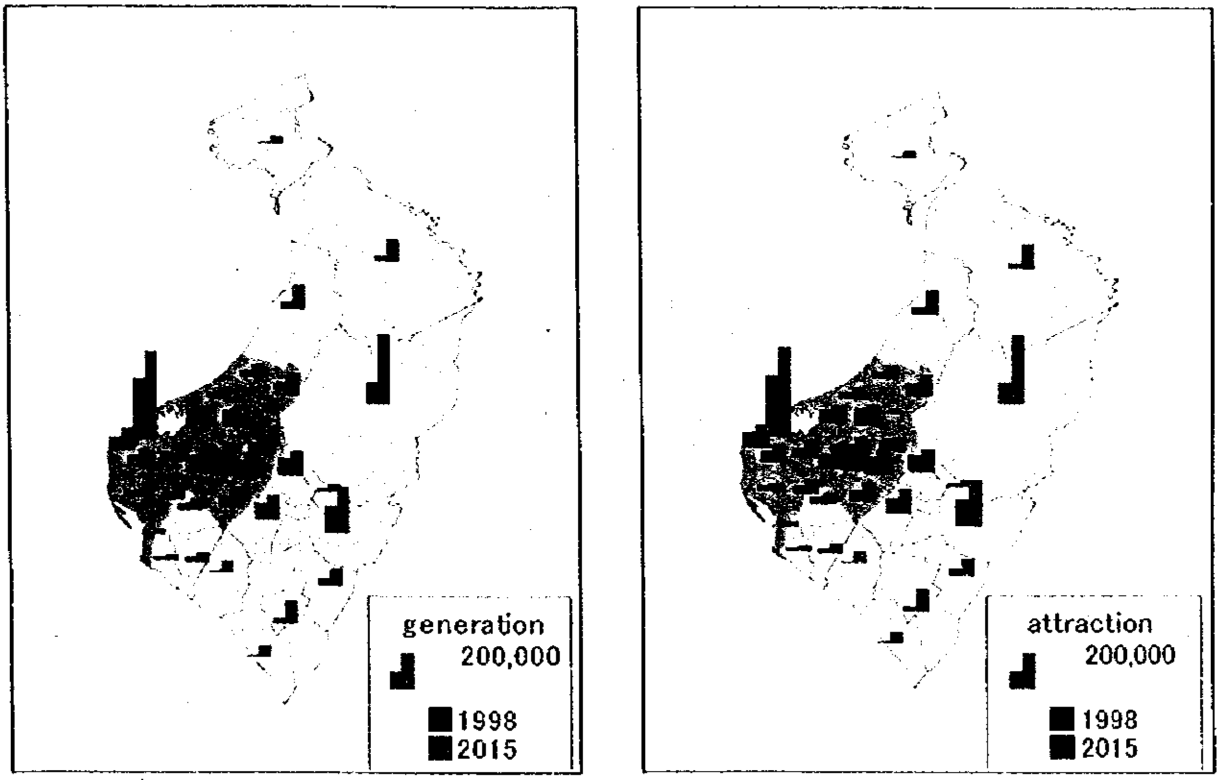

Fig. 10-2-1 Generation and Attraction

10.3 Trip Distribution

10.3.1 Trip Distribution Model

Trip distribution model is developed applying the following Vorhees type gravity model. The parameters by trip purpose are shown in Table 10-3-1.

$$Tij = Gi(AjDij^{**}g) / \sum AjDij^{**}g$$

Where,

Tij	*Trips between zones i,j*
Gi	*Generated trips from zone i*
Aj	*Attracted trips to zone j*
Dij	*Distance between zones i,j*
g	*Parameter*

Table 10-3-1 Parameters of Trip Distribution Model

	Purpose	G
Car	To work	-0.1703
	To study	-0.4155
	Related to work	-0.2563
	Others	-0.3389
Bus	To work	-0.1301
	To study	-0.1816
	Relate to work	-0.1617
	Others	-0.2033

10.3.2 Intra-Trip Model

The intra-trip models by mode and purpose are developed by linear regression analysis, and the variables and parameters are shown in Table 10-3-2.

$$Tii / A = a1\ (Gen / A) + a2\ (Att / A) + a3\ D1 + a4\ D2 + a0$$

Where,

Tii	*Intra-zone trips in zone i* .	*D1,D3,D5,D7,d1,d3,d5,d7*	*Dummis for under-estimated zone*
A	*Area of zone i*	*D2,D6,D8,d2,d4,d6,d8*	*Dummis for over-estimated zone*
Gen	*Generated trips from zone i*	*D9*	*Ita pyta Punta (Zone48) Dummy*
Att	*Attracted trips to zone i*	*D10*	*Samtisma Trinidad (Zone 37) Dumm*
a0-a4	*Parameters*	*d9*	*R.de Francia (Zone 33) Dummy*

Table 10-3-1 Parameters of Intra Trip Model

Purpose		1st		2nd		3rd		4th		Constant	Co-relation
		Variable	Parameter	Variable	Parameter	Variable	Parameter	Variable	Parameter		
Car	To work	Gen/A	0.031	Att/A	0.012	D1	354.981	D2	-137.416	0.257	0.946
	To Study	Att/A	0.025	D3	249.709	D9	603.664			18.359	0.954
	Trips related to work	Att/A	0.038	D5	71.649	D6	-44.008	D10	206.231	-2.695	0.947
	Others	Gen/A	0.126	D7	152.503	D8	-142.820			-28.432	0.946
Bus	To work	Gen/A	0.021	d1	219.945	d2	-114.324	d9	519.055	5.205	0.928
	To study	Att/A	0.010	d3	44.907	d4	-42.576	d9	118.671	2.941	0.918
	Trips related to work	Att/A	0.013	d5	23.020	d6	-19.066	d9	60.258	1.710	0.911
	Others	Gen/A	0.018	d7	98.912	d8	-47.683	d9	225.393	3.175	0.927

10.3.3 Future Traffic Demand

(1) All-Trip, All-Mode Traffic Volume

Future distribution of traffic volume is shown in Fig.10-3-1. Compared to 1998, the following trends can be observed.

- Attraction of traffic to the central district of Asuncion remains unchanged.
- The major traffic flow exists in the east-west direction from San Lorenzo to Fdo. de la Mora to Asuncion, but an increasing volume flows into Asuncion from the north, Luque, Limpio, and M. R. Aronso.
- There will be an increasing traffic volume in a circular direction connected by Limpio, Luque, and San Lorenzo.

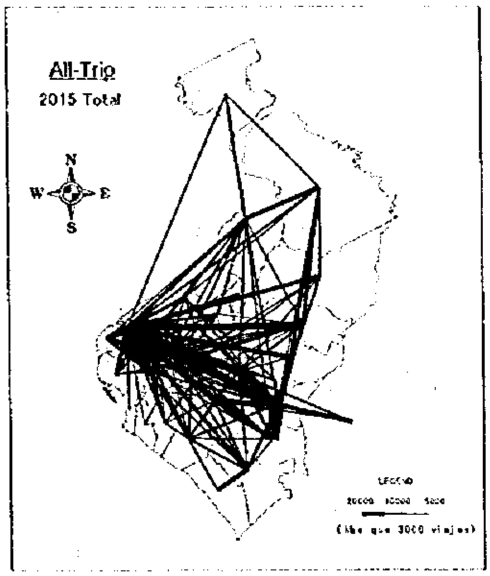

Fig. 10-3-1 Desire Line for All Trips by All Modes in 2015

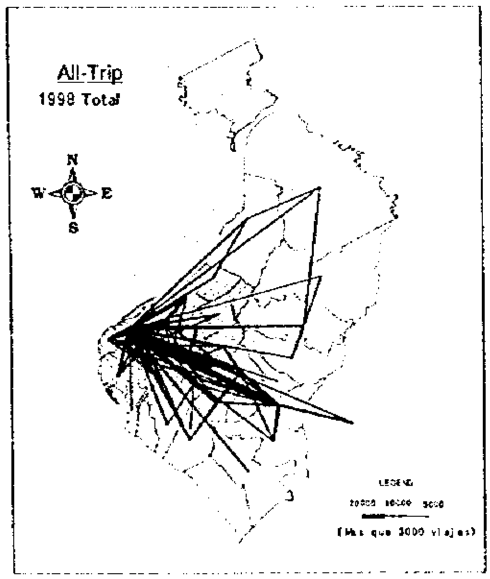

Fig. 10-3-2 Desire Line for All Trips by All Modes in 1998

(2) Distribution of Traffic Volume by Purpose

Fig.10-3-3 to Fig.10-3-6 show future desire lines by purpose, i.e. work, school, business, and others. There are more work trips in linear directions connecting each suburban city with Micro Centro and in the suburban circle. More business trips are made in the east-west direction connecting San Lorenzo, Fdo. de la Mora, and Asuncion. Desire lines for other trips are extended longer, compared to trips for other purposes.

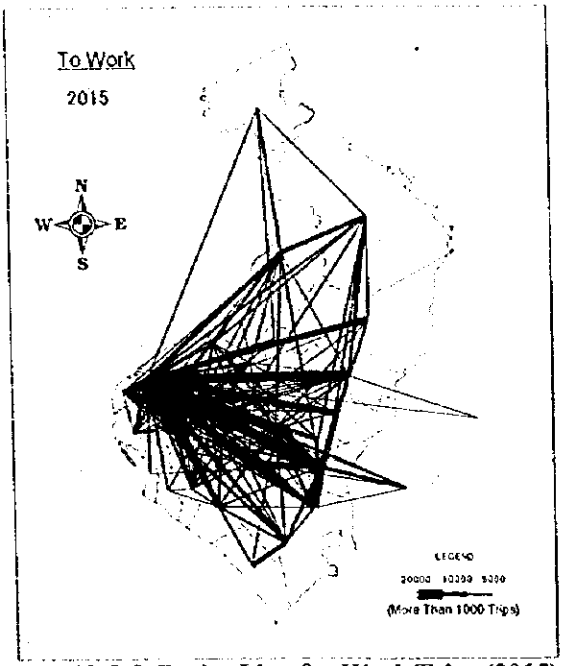

Fig. 10-3-3 Desire Line for Work Trips (2015)

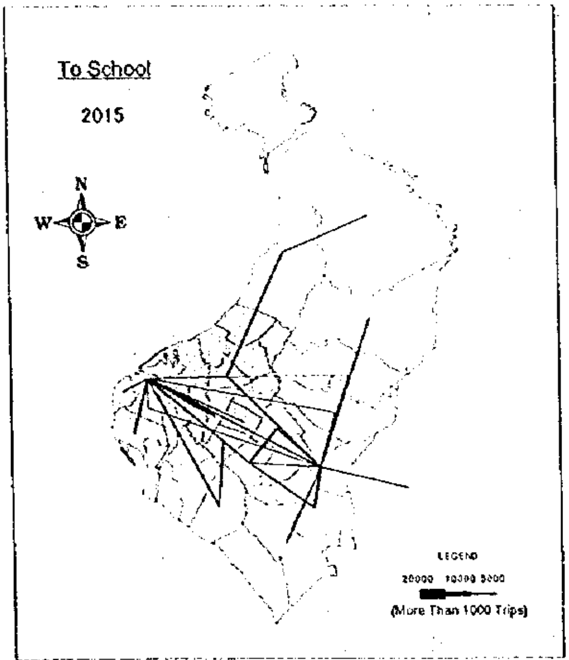

Fig. 10-3-4 Desire Line for School Trips(2015)

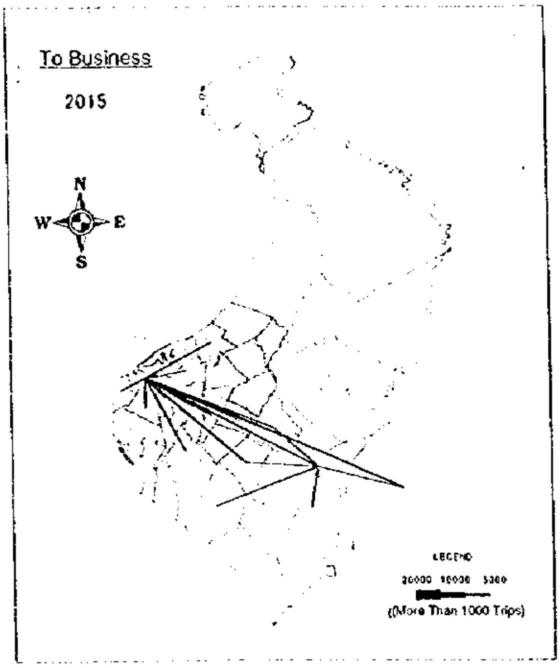

Fig. 10-3-5 Desire Line for Business Trips (2015)

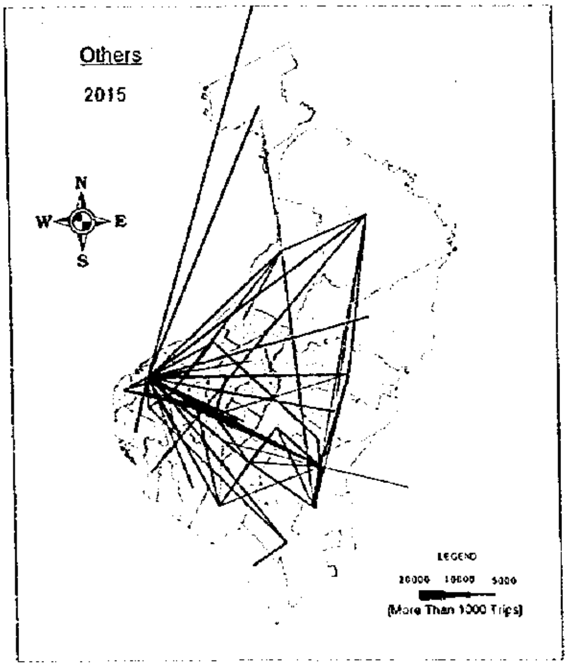

Fig. 10-3-6 Desire Line for Other Trips (2015)

(3) Traffic Volume by Vehicle Type

In 2015, the traffic volumes of omnibus and auto will be distributed in a larger area than in 1998. Bus trips remain attracted to Centro of Asuncion, but there will be some increase in the circular direction of Limpio, Luque, and San Lorenzo. Auto trips toward Centro of Asuncion will increase, but the increase is even more prominent in the circular direction and in the north-south direction between M. R. Aronso, Limpio, Lambare, and Fdo. de la Mora. In the east-west direction, more trips will be distributed widely and reach Capiata and Caacupe.

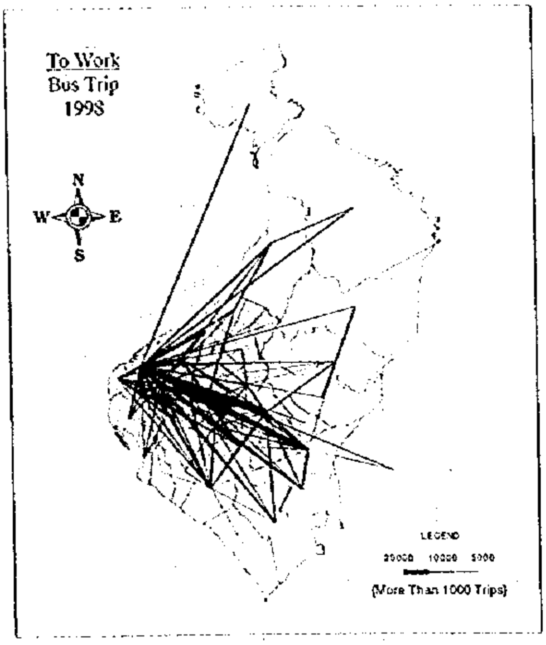

Fig. 10-3-7 Desire Line for Bus Trips (1998)

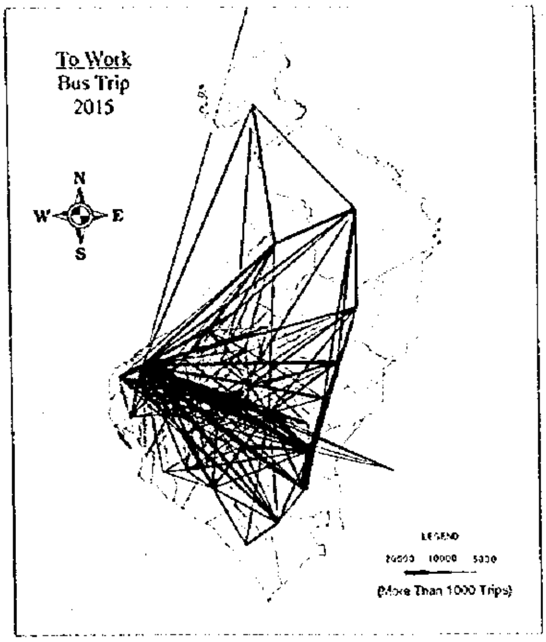

Fig. 10-3-8 Desire Line for Bus Trips (2015)

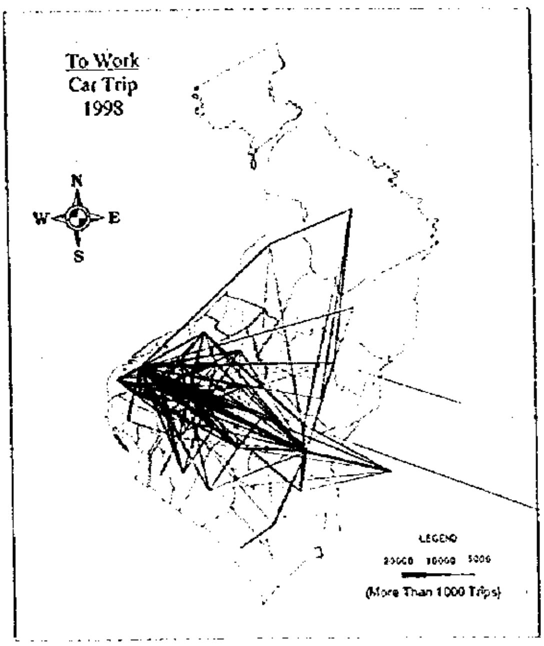

Fig. 10-3-9 Desire Line for Car Trips (1998)

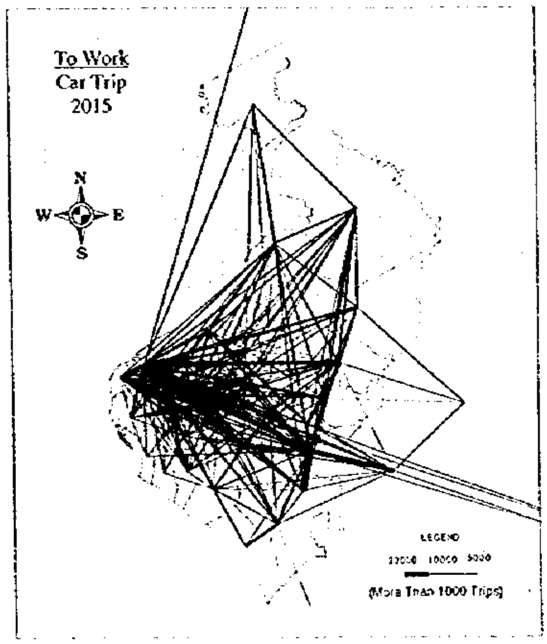

Fig. 10-3-10 Desire Line for Car Trips (2015)

10.4 Traffic Assignment Model

Traffic assignment is carried out in the following two steps;

- Assignment of public transport passengers to public transport routes
- Assignment of vehicle demand on the road network by the equilibrium assignment with capacity constraint formula of BPR (Bureau of Public Road, USA) and with overlay flow of buses calculated in the first step.

(1) Public Transport Passenger Assignment Model

The network for assignment is limited to the bus route network. There are two steps in the public transport assignment model.

In the first step, 10 prospective paths, at maximum, used for each O-D pair are selected, taking into account its generalized travel time computed using time for boarding, waiting, transfer, and walk, and fare constraint. In selecting them, different bus routes with the same line number (e.g. Linea 12) are regarded as a single path, and only those paths with generalized travel time within 1.5 times of the minimum are selected for modeling.

Next, the volume of each OD pair is distributed among the selected paths, and the number of users is computed accordingly. In so doing, the distribution rate onto each path is calculated by the Formula 10-4-1.

$$Distribution\ Rate = \frac{RouteCostRatio}{RouteCostRatioofAllRoutes} \quad \text{------------------------ (Formula 10-4-1)}$$

$$RouteCostRatio = \frac{Cost_m{}^{\prime}}{\sum Cost_m{}^{\prime}} \quad \text{-- (Formula 10-4-2)}$$

Where: $Cost_m$: *Generalized cost for m route*

$=T^1*M^{m,1}+T^2*M^{m,2}+T^3*M^{m,3}+T^4*M^{m,4}+T^5*M^{m,5}+T^6*M^{m,6}$

T^i: *time value of cost component i*

1) Boarding Time
2) Wait Time
3) Transfer Time
4) Walk Time (Walking velocity=5km/h)
5) Fare
6) Congestion factor

$M^{m,l}$: *Route – weighing coefficient of component l of route m*

Cost components are explained below.

1) Boarding time

Time on board the bus. Calculated from travel speed of the bus.

2) Wait time

Time for waiting for the bus. In proportion to bus frequency. The following formula is used, assuming the maximum wait time of 50 minutes.
Wait Time = (Head way/2) - ($Headway^2$)/200

3) Transfer time

Time for transferring between two bus stops. It is uniformly assumed to be two minutes.

4) Walk time

Time for access and egress to bus stops. Walking speed is assumed to be 5km per hour.

5) Fare constraint

Time value of bus users is Gs20.5 per minute. The current bus fare, Gs850, is thus equivalent to about 41 minutes.

6) Congestion factor

Users tend to avoid congested buses and choose to ride another one. Here, the following formula is applied when the congestion factor is over 0.8.
Boarding time x (Congestion Level x 5.0 – 4.0)

Weight (M) of each component is set as follows after a trial calculation.

Table 10-4-1 Weight Coefficient

Component	Weight Coefficient
Boarding Time	1
Wait Time	2
Transfer Time	5
Walk Time	3
Fare Constraint	1
Congestion Factor	100

*:Convert for equivalent time

Fig. 10-4-1 shows the relationship between the number of actual users and that of the estimates on each individual line, and the model indicates the correlation coefficient of 0.616. However, as a result of integrating 117 bus lines into 20 groups by putting together competing lines passing identical paths, the coefficient is found to be much higher, 0.98, as shown in Fig. 10-4-2. Accordingly, it can be said that this model can make more accurate estimate for certain competing lines than for individual lines.

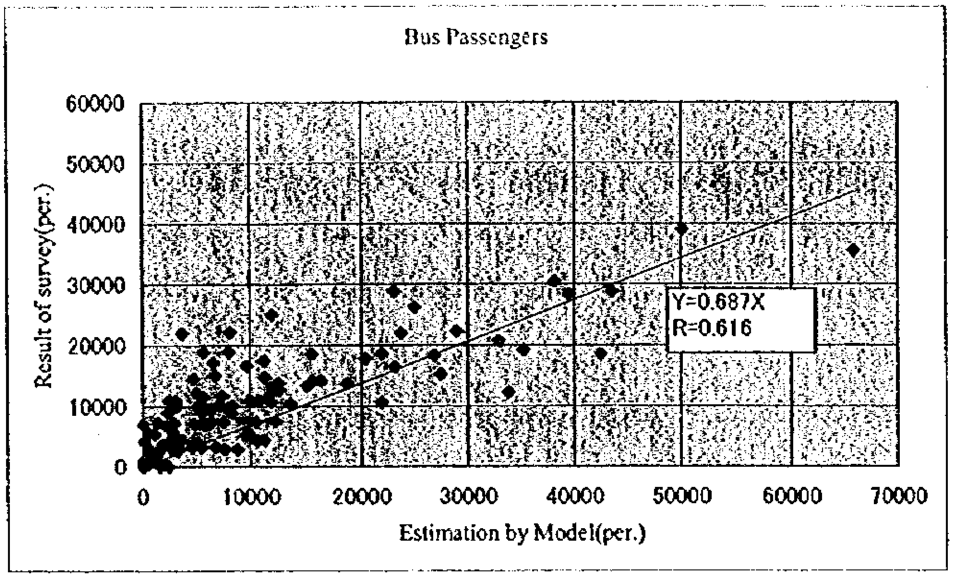

Fig. 10-4-1 Bus Passenger between Survey and Model

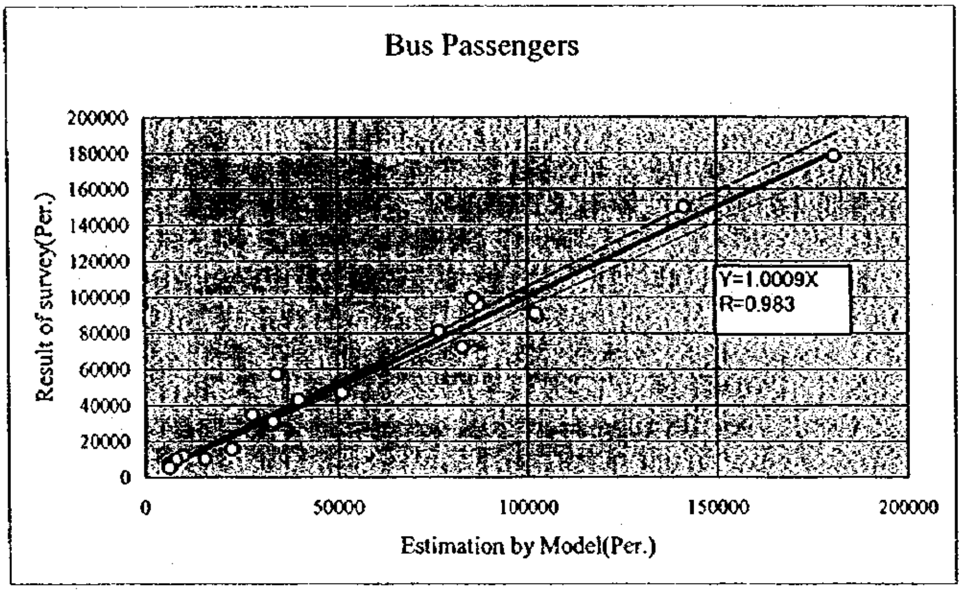

Fig. 10-4-2 Bus Passenger between Survey and Model (competing routes)

Table 10-4-2 Groups of Competing Bus Routes

No.	Groups	Routes
1	San Lorenso- Lambare	50-2
2	Este-Oeste	54-0
3	Asuncion Norte-Mcal.Lopez-Micro Centro	16-0
4	San Lorenso-Mcal.Lopez-Micro Centro	12-1,12-2,12-3,12-4,12-5,26-4,55-0,56-0
5	Asuncion Norte	1-1,1-2,37-1
6	Ruque-Asuncion	51-1,51-2,51-3
7	Circunvalacion(Norte)	13-1,13-2,13-3,13-4,36-1,36-2,42-0
8	Circunvalacion(Sul)	41-1,41-2
9	Norte-Sul	18-4,48-2,49-1,49-2
10	Circunvalacion(Asuncion)	3-1,3-2,15-3,15-4,18-2,18-3
11	Secundaria-Micro Centro	22-1,22-2,22-3
12	Norte-Artigas-Micro Centro	2-1,2-2,6-1,6-2,23-0,37-2,401-,40-2,44-3
13	Sul-Fdo.Mola-Micro Centro	8-1,8-2,15-5,38-1,38-3,38-4,38-5,38-2,50-1
14	Sul-Micro Centro	15-1,18-1,47-0
15	Norte-E.Ayala-Micro Centro	7-0,17-0,21-2,26-3,33-1
16	Norte-Asuncion	34-1,34-2,34-3,34-4,34-5,34-6,34-7,48-1
17	San Lorenso-E.Ayala-Micro Centro	11-2,19-1,20-1,27-0,29-1,29-2,43-0,45-0,59-0
18	Sul-E.Ayala-Micro Centro	10-1,10-2,15-2,21-1,21-3,25-0,26-1,26-2,33-2,33-3,39-1,39-2,39-3,39-4
19	Luque-Micro Centro	11-1,28-0,30-1,51-1,51-2,51-3
20	Sul - Microcentro	4-0,9-1,9-2,14-0,19-2,31-1

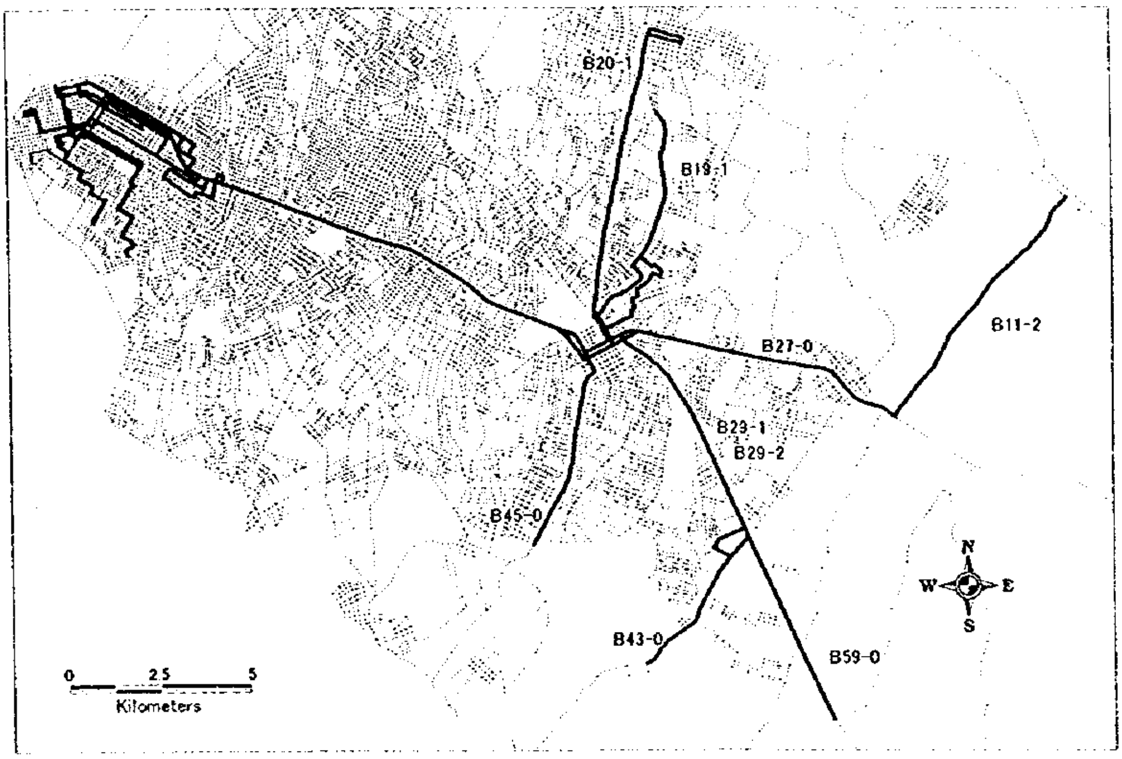

Fig. 10-4-3 Example of Competing Line (Group 17)

(2) Vehicle Demand Equilibrium Assignment Model

In the vehicle demand assignment, the free flow speed and traffic capacity are estimated by conditions of road surface, areas along roads, etc. Formulas for calculating traffic capacity are shown below, and the free flow speeds by category are shown in Table 10-4-3. They are summarized in Table 10-4-4.

- Multi-Lane Road: *Qc = Qs x N/2 x 100/K x 100/D x fn x fs*
- 2 Lane 2-way Road: *Qc=Qs x N/2 x 100/K x fn x fs*
- 2-Lane One-Way Road *Qc=Qs x N x 100/K x fn x fs*

Where,
Qc: Traffic capacity (vehicle/day): See Table 10-4-4
Qs: Basic traffic capacity (vehicle/hour): See Table 10-4-5
N: Number of Lanes
K: K-factor: See Table 10-4-6
D: D-factor: See Table 10-4-7
fn: Area type factor: See Table 10-4-8
fs: Service level factor: See Table 10-4-9

Relationships between traffic volume and velocity can be expressed by relationships between congestion and travel time obtained from the following BPR formula. Generally in the United States, a = 4 and k = 0.15 are assumed.

$$Tc = T0\,(1 + k\,(Q/C)^{a})$$

Where,
Tc: Travel Time
T0: Travel Time by Free Flow Speed
Q: Traffic Volume
C: Capacity
a, k: Parameters

In Asuncion, traveling speed is about half of the limits when congestion factor is 1.0. And thus the parameter, k, is set at 1.0. As a result, relationships between speed and congestion are the same as what is shown in Fig.10-4-4, and then the speed has been computed under the equilibrium condition. For reference, Fig.10-4-5 shows the relationship between speed and congestion with the parameters used in the United States.

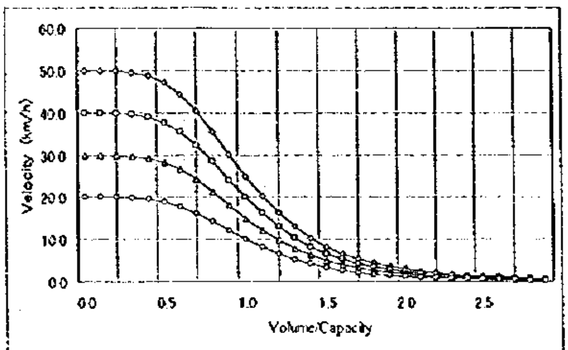

Fig. 10-4-4 BPR Formula (Asunción)

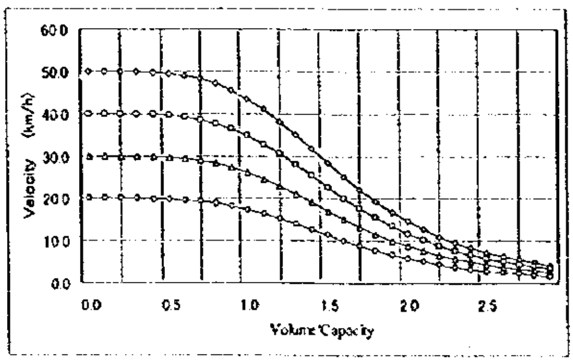

Fig. 10-4-5 BPR Formula (USA)

Table 10-4-3 Free Flow Speed

Area	Pavement						Stoned - Pavement
	Trunk		Sub-Trunk	Minor	Expressway	National Road	
	Radial road	Circular road					
Center	40	35	35	30	80	40	20
Urban	50	45	40	35	80	50	20
Others	60	60	50	40	80	60	20

Table 10-4-4 Traffic Capacity and Free Flow Speed

Pavement	Category	lane	Area	Regulation	Direction	Velocity	Type of Area	Service Level	Capacty (UVP/day)
1 Pavement	Expressway	6	-			80	-	1	88,800
2		4	-			80	-	1	59,200
3		2	-	One way		80	-	1	29,600
4 Pavement	Route	4	Other			60	-	1	64,200
5		2	Other			60	31	1	30,300
6 Pavement	Principal	6	Urban			50	22	1	66,600
7		4	Other			60	32	1	64,200
8		4	Urban			50	22	1	44,400
9		4	Urban		Circulation	45	22	1	47,600
10		4	Center	One way		40	12	1	38,400
11		4	Center	One way		40	12	1	38,400
12		4	Centro			40	12	1	32,000
13		4	Center		Circulation	35	12	1	34,200
14		2	Other			60	31	1	30,300
15		2	Urban	One way		50	22	1	26,600
16		2	Urban			50	21	1	20,700
17		2	Urban	One way	Circulation	45	22	1	26,600
18		2	Urban		Circulation	45	22	1	22,200
19		2	Center	One way		40	21	1	19,200
20		2	Center			40	11	1	14,600
21		2	Center		Circulation	35	11	1	15,700
22 Pavement	Secondary	4	Other			50	32	2	72,300
23		4	Urban		Circulation	40	22	2	53,500
24		4	Urban			40	22	2	50,000
25		4	Center		Circulation	35	12	2	38,500
26		4	Center			35	12	2	36,000
27		3	Center	One way		35	12	2	54,000
28		2	Other			50	31	2	34,100
29		2	Urban	One way		40	12	2	30,000
30		2	Urban		Circulation	40	21	2	25,000
31		2	Urban			40	21	2	23,300
32		2	Center	One way		35	12	2	21,600
33		2	Center		Circulation	35	11	2	17,600
34 Pavement	Minor	4	Other			40	31	3	80,300
35		4	Urban			35	22	3	59,500
36		4	Center	One way		30	12	3	48,000
37		4	Center			30	12	3	42,800
38		3	Center	One way		30	12	3	36,000
39		2	Other			40	31	3	37,900
40		2	Urban	One way		35	22	3	33,300
41		2	Urban			35	21	3	27,700
42		2	Center	One way		30	12	3	24,000
43		2	Center			30	11	3	19,600
44		1	Center	One way		30	11	3	12,000
45 Pavement	Minor	4	Other			20	32	3	10,000
46		4	Urban			20	22	3	6,900
47		4	Center			20	12	3	5,300
48		2	Other			20	31	3	4,700
49		2	Urban			20	21	3	3,200
50		2	Center			20	11	3	2,200
51		2	Other	One way		20	31	3	2,600
52		2	Urban	One way		20	22	3	2,000
53		2	Center	One way		20	12	3	1,500

Table 10-4-5 Basic Capacity

Pavement	Multi Lanes	2000	Vehi./h, lane
	2 lanes	2000 lanes	Vehi./h, 2
Stoned Pavement		125	Vehi./h, 1 lane

Table 10-4-6 K-Factors

Zone	Coefficient(%)
Center	10
Urban	9
Others	8

Tabel 10-4-7 D-Factors

Zone	Redial Road	Circular Road
Center	60	56
Urban	60	56
Others	56	

Table 10-4-8 Area Factors

Level	Roads	Coefficient
1	Trunk, National Road, Expressway	0.8
2	Sub-Trunk	0.9
3	Minor	1.0

Table 10-4-9 Service Level Factors

Zone	2 Lanes Two-way	4 Lanes 2 Lanes One-Way
Center	0.55	0.60
Urban	0.70	0.75
Others	0.85	0.90

Chapter 11 Policy for Plan Formulation

11.1 Planning Background

11.1.1 Socioeconomic Framework

Located between Brazil and Argentina, Paraguay is under tremendous influence from these two large countries. Fluctuations in their foreign exchange rates affect the foreign trade, financial market, and tourism of Paraguay, which directly affects the economy of the Asunción Metropolitan area. In particular, since Paraguay has no protection policy for its domestic industry and imposes relatively lower tariff rates, it imports foreign goods at low tariff rates for both its domestic consumption and re-exportation to neighboring countries. Therefore, the complete opening of the common market in Latin America (MERCOSUR) in 2006 will affect the economy of Paraguay. The recent economic recession can be seen as a sign of this beginning.

This Study projects 3.5 percent, in real terms, on average, of economic growth rate by tracing the past trend. The tertiary industry registers the highest growth rate, whereas the primary, the lowest. The growth of the secondary industry is roughly the average of the two. Although the economy of the greater Asunción area will grow faster than the national average, it will eventually come close to it, and the population concentration in the capital area will gradually subside.

11.1.2 Traffic Demand

The total number of trips excluding pedestrian and bicycles will increase from 2.15 million trips/day in 1998 to 3.81 million trips/day in 2015, or by 1.77 times.

Without any transport policy implemented, the mode that increases trips most rapidly is passenger vehicle. The number of passenger car trip will increase from 1.02 million to 1.96 million and that of bus trips from 1.13 million to 1.85 million, or by 1.92 and 1.63 times, respectively.

11.1.3 Land Use

The center of the greater Asunción capital area called Micro Centro has the concentration of commercial, business, and political functions and forms a unitary urban core. However, the over-concentration in Asunción including Micro Centro in recent years has led to the relocation of various urban functions outside Asunción, Fernando de la Mora, and Lambaré.

This trend will continue for years to come, and the population increase in the capital area will directly be translated into growth in Luque, San Lorenzo, and other cities. The proposed form of urban structure is a multi-core urban complex that can alleviate the over-concentration at the center of Asunción by creating new sub-centers.

11.1.4 Funding Sources for the Plan

There are two organizations responsible for road planning: MOPC at the national level for inter-city roads and the Municipality for intra-city roads. One of the main organizations of the latter type is Asociation de Municipalidades del Area Metropolitana (AMUAM), which consists of the municipalities in the area. There is no organization for road administration at the provincial (*departomento*) level.

Available funding sources for projects in Asunción are the budgets of the municipality and the AGA. The funds of the two organizations are almost the same, or about 2.5 million US dollars each annually, and they are not sufficient for a large-scale project. It is necessary, therefore, to consider financing schemes by looking for new sources including practical use of private sector funds such as PFI or BOT, and studying coordination with other international organizations such as the World Bank, Inter-American Development Bank, and OECF.

11.2 Basic Policy for Sectoral Plan

11.2.1 Overall Policy

1) Maintaining the Current Level of Service

Without the implementation of transport policies, there would be serious traffic congestion. The more improvements it makes, the more traffic congestion will be alleviated. However, it depends on available funding sources and a desirable level of service to decide to what extent the improvement should be made. This Study will attempt to maintain at least the current level of operating speed of buses.

2) Respect for Existing Plan

In 1995, the Municipality of Asunción, together with FLACAM and CEPA, formulated a master plan, Plan Director de Desarrollo Urbano Ambiental, or PDUA, and the current road administration of Asunción follows it. This Study also respects the Plan and incorporates the proposed projects after evaluating their effects.

3) Formulation of Implementable Plan

It is highly likely that due to the funding limitations, some projects would not receive the priority that they deserve from the standpoint of traffic demands. Therefore, it is one of the most important policies of this Study to start with projects that are implementable and can produce some effects so that by 2015, the basic plan can be completed.

11.2.2 Public Transportation Plan

Public transportation plan puts an emphasis on the bus. It is in dispensable to reinforce public transportation in order to handle an increasing traffic demand with the existing road network. This Plan will identify problems arising when the current bus network attempts to handle public transport demands by 2015 and examine measures to solve these problems.

The central issue is the introduction of a trunk bus system on Av. Ayala. It is designed to improve the level of bus service and transport efficiency by introducing new high-speed, medium-distance, large-scale buses. This plan also suggests restructuring of bus routes and fare structure taking trunk bus routes into account. In addition, there will be some institutional suggestions on an operating body for the trunk bus. Furthermore, since the time will eventually come when the trunk bus system cannot accommodate increasing demands, the timing of

introducing a new transport system will be determined by a financial analysis.
Currently, the national railroad does not serve as an effective urban transportation mode. However, since its modernization will cost substantially, it will be determined whether or not to continue its operation, examining an option of converting the right-of-way into a road.

11.2.3 Road Network Plan

In radial directions, main corridors will be identified and improved intensively. In circular directions, it is stressed that roads connecting suburban cities will be improved.

In response to inflow traffic into Micro Centro, roads on the edge of the district will be improved and strengthened. It is proposed that bus traffic be directed to enter the district from the east and the west. On the other hand, passenger vehicle traffic flow that currently enters the district mainly from the east and the west will be changed and induced to enter it from the south and the north. In Micro Centro, moreover, traffic will be separated by mode.

Within the city of Asunción, roads are classified into either collectors or local roads. New pavement projects will be promoted in order to improve the ease of driving on minor arterials. Moreover, main arterials for public transportation will be given a priority for improving necessary facilities.

11.2.4 Traffic Management Plan

Since it is expected to produce some positive effects on congestion alleviation with low costs, traffic demand management to control general use of vehicles deserves attention. What type of measures can be introduced in the Study area will be examined. Management methods can be generally classified into three: controls on vehicle ownership, controls on vehicle use, and promotion of alternative modes. It is also necessary to examine measures to control and divert traffic demand.

11.3 Consideration for the Environment

Air pollution in Asunción is not a serious problem yet, according to the existing data and survey results, but road noise surpasses the standard of Asunción city.

Air pollution and noise are expected to worsen as traffic volume increases, and it is necessary to take some measures against the sources of their origins, such as more strict vehicle inspections, conversion of roadside buildings into high-rise, etc. In addition, it is proposed that a monitoring system be established to carry out a continuous collection of environmental data.

Chapter 12 Public Transport Plan

12.1 Demand Structure

Table 12-1-1 shows the public transport passenger demand by section and by year. The demand at the Asunción city border shows the highest Fig. ure among the sections and also the highest demand increase from 1998 to 2015. The public transport passenger demand entering Micro Centro is 60% of that crossing the Asunción city border, which implies that the present bus operation concentrating to Micro Centro does not match the passenger demand structure.

Table 12-1-1 Section Passenger Demand

(passengers/day)

Section	1998	2015	2015/1998
City Border	444,867	721,250	1.76
Screen	500,144	637,300	1.40
Gral Santos	494,321	637,041	1.42
Micro Centro	306,752	429,241	1.52

The 2015 bus passenger demand assigned to the 1998 bus route network is shown in Fig. 12-1-1. Fig. 12-1-2 shows bus operation frequencies necessary to meet this demand. The most frequent service is provided on the section between Av. Gnel. Santons and Gnel. Aquino on Av. E. Ayala with over 10,000 buses per day. Av. Mcal. Estigarribia in Fdo. de la Mora is served by more than 7,500 buses per day.

Fig. 12-1-3 shows a daily average occupancy rate (passengers/bus capacity x number of buses). It indicates that the rate is nearly 100% in the section between Av. E. Ayala and Av. Mcal. Estigarribia in Fdo. de la Mora. However, the closer it is to Centro, the lower the rate, and it is below 50% even in the most frequently serviced section. That is, the number of buses is more than necessary, and thus it has negative impacts on traffic congestion as well as the efficiency of bus company operation. On major bus corridors, a similar tendency can be observed, and the occupancy rate becomes increasingly lower toward Centro. It is less than 50% in Centro and below 25% in Sajonia.

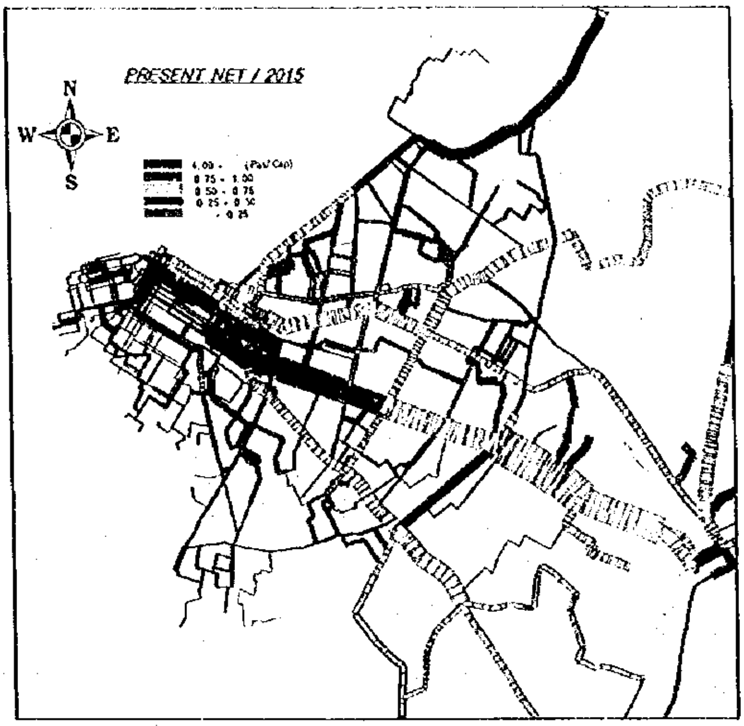

Fig. 12-1-1 Bus Passengers under Do-Nothing Case in 2015

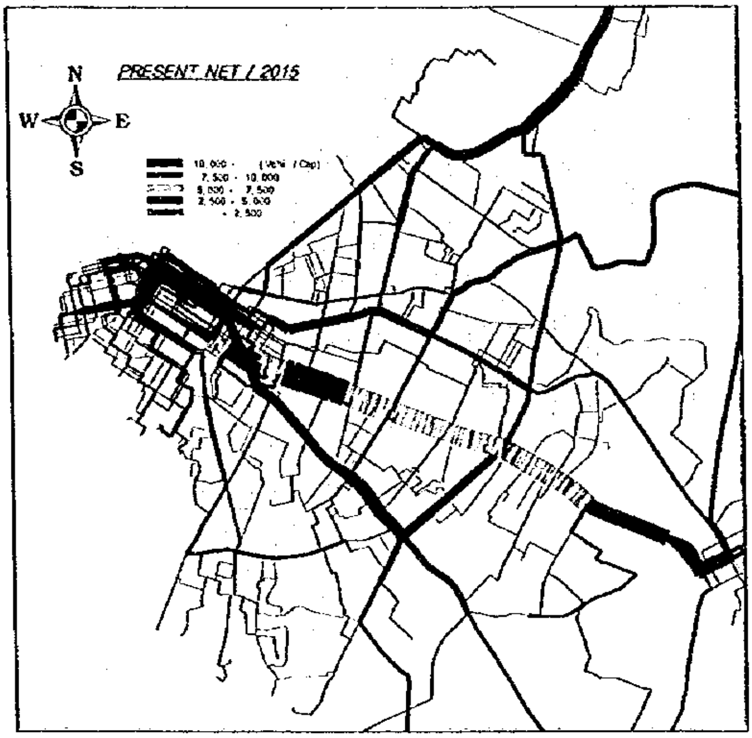

Fig. 12-1-2 Bus Frequency under Do-Nothing Case in 2015

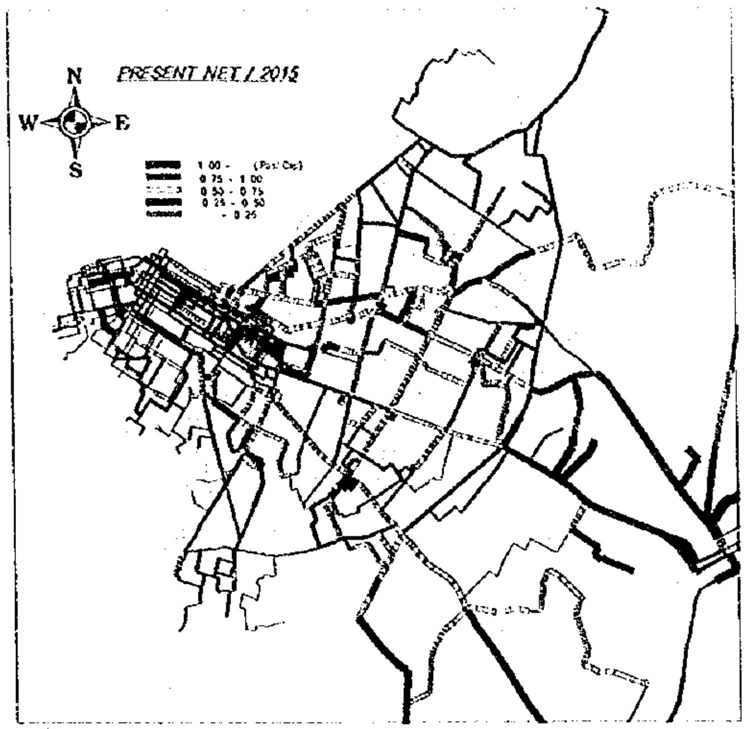

Fig. 12-1-3 Occupancy Rate under Do-Nothing Case in 2015

12.2 Planning Policy

(1) Organization of Bus Operating Bodies

All the buses in Asunci6n metropolitan area are operated by small- and medium-scale private bus companies, and the excessive competition causes various traffic problems on roads and financial problems to the bus companies. Thus, these bus companies should be streamlined and make their operations more efficient while satisfying the passenger demand. One of the alternatives is to integrate some of the lines sharing the same destinations. This will require institutional arrangements to redistribute profits. The public sector should change its role from the present licensing of the bus operation into a more active involvement in encouraging coordination among bus companies by monitoring their operation, profits, etc.

In sum, this Study recommends the most practical way of organizing bus operating companies and required roles of the public sector, including the Asunci6n city and other relevant agencies.

(2) Introduction of Hierarchy

In Asunci6n Metropolitan Area there exists only one kind of bus as a mode of public transport. However a hierarchy system should be introduced and trunk bus, ordinary bus should divided according to its function.

1) Trunk bus

Trunk bus with high capacity, high velocity and high quality will be introduced on Avenida E.

Ayala and other radial principal arterials.

2) Ordinary bus

The functions of ordinary buses are between these of trunk buses and feeder buses, and many features of existing ordinary buses will continue to be as at present.

3) Feeder bus

Feeder buses act as to supplement trunk buses and ordinary buses connecting with them at bus terminals or principal bus stops.

(3) Introduction of Trunk-Feeder Bus Services

One of the forms of integrated bus service is the trunk-feeder bus service. The present bus lines in the Asunción metropolitan area include area service and long-distance linear service. Route distances are expected to be longer as low-density urbanization spreads in future. Moreover, about 70% of the present bus lines concentrate in Micro-Centro, which causes excessive competition on main radial roads and also traffic accidents. In view of these conditions, trunk-feeder bus services should be introduced on linear bus sections with a high volume and frequent services.

The system also requires an organization of the existing bus companies to redistribute profits among the member companies. It is necessary to provide exclusive bus lanes to secure reliable bus operation and transfer terminals between trunk and feeder bus lines to minimize transfer impediments for passengers.

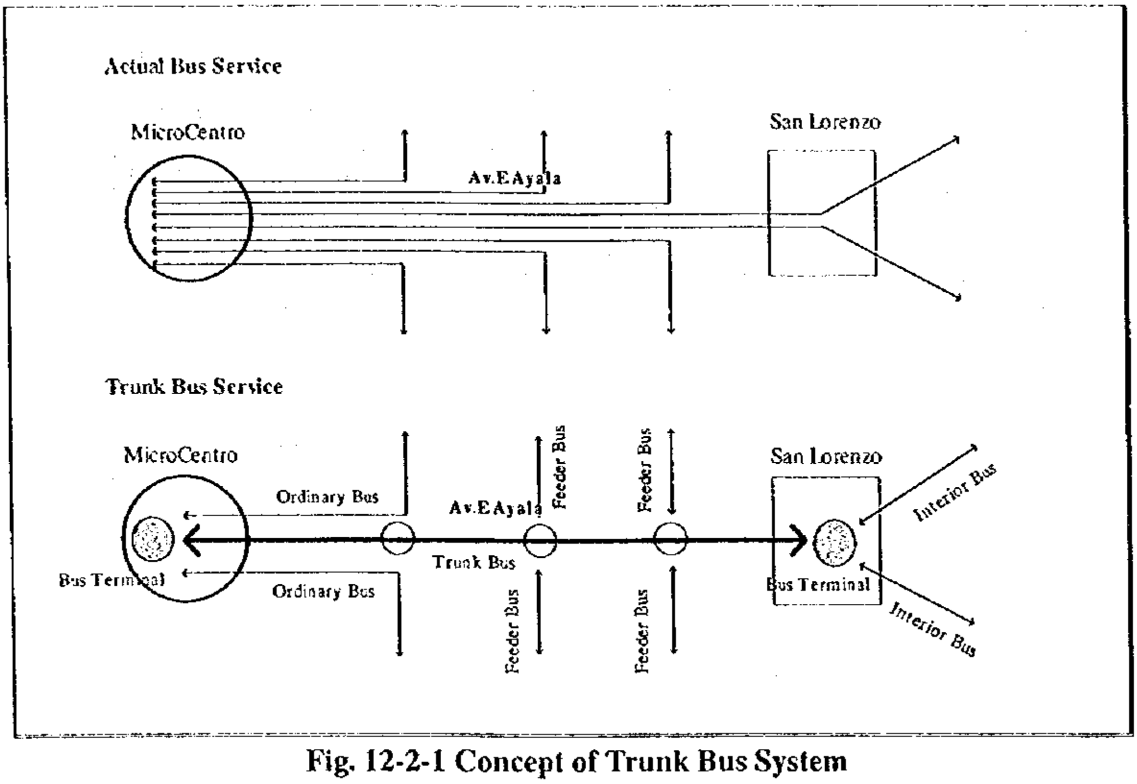

Fig. 12-2-1 Concept of Trunk Bus System

(4) Improvement of Bus Fleet

The average vehicle age of the bus fleet operating in the Asunción metropolitan area is 15-years old, and no emission control against air pollution exists at present. This situation is caused by the lack of initial investment in each bus company and financial support by the public sector to make buses more environmentally friendly.
The bus fleet renovation system will be one of the measures to require the existing bus companies to conform to the inspection system and impose restrictions on buses with excessive emissions. The public sector should establish a special unit responsible for vehicle controls and a financial support system to help promote bus renovations among bus operators.

Moreover, private vehicle users view the importance of "convenience" in selecting their modes of travel (See Table 3-4-2). This indicates that the conversion from private vehicles into buses can be achieved if the convenience of the bus is improved. Convenience can be defined in terms of congestion in the bus, cleanliness of vehicles, and safety, and bus renovation is the very thing to improve this " convenience." Table 12-2-1 shows the results of the computation for the number of converted trips from private vehicles to buses, using the logit type disaggregate model in 3.4.2. In 2015, 68,629 trips, or 3.1% of the total auto trips, can be converted with a renovation rate of 50%, and 150,234, or 6.9%, with the 100% renovation rate. Converted into the number of vehicles, 42,627 and 93,313, respectively, can be reduced on roads. Not only can the promotion of bus renovation help clean up the environment, but also increase fare revenues of bus companies and alleviate congestion by reducing traffic accidents.

Table 12-2-1 Passenger Increase by Bus Renovation

		1998	2015		
			Do nothing	Renovation=50%	Renovation=100%
Car	(T.E)	1,138,960	2,182,261	2,113,622	2,032,027
	(Vehi.)	758,033	1,355,442	1,312,809	1,262,129
Car->Bus	(T.E)			68,629	150,234
	(Vehi.)			42,627	93,313
Bus	(T.E)	1,150,214	1,879,831	1,948,470	2,030,065
	(Vehi)	54,800	82,521	85,534	89,116

The number of vehicles is computed by dividing trips by the average occupancy.
Car = 1.61 passengers/vehicle, Bus = 22.78 passengers/vehicle

(5) Bus Network to Support Future Rail Transit System

The existing railway in the Asunción metropolitan area is not used as a viable mode of urban transport because of its deteriorated infrastructure, including rolling stocks, and low passenger demand. The public transport demand from sub-urban areas, especially from Luque, is forecast to increase rapidly.

The introduction of an urban railway system to the metropolitan area requires a huge amount of initial investment, and therefore, this is beyond the power of local authorities. However, from a long-term viewpoint, it is necessary to introduce rail transit on the existing right-of-way or in other areas. The bus improvement plan of this Study will consider the possibility of introducing rail transit in the near future. It is possible to surface the environmental problem such as air pollution, and so on along main roads and in the Centro area in future. Therefore we should consider introducing mass transit system such as a railroad.

12.3 Introduction of a New Transportation System

With the existing bus route network, there will be a demand for 11,720 buses/day/section on Av. E. Ayala in 2015. Multiplied by the peak rate of 6.9%, there will be 404 buses/peak hour for a single direction. An average number of passengers is 38 (309,000 passengers/day/section x 10% x 0.5). Supposing a stopping time of 30 seconds, one bus stop would be able to manage only 120 buses per hour. Each bus stop would need to be capable of handling four buses simultaneously, but heavy traffic congestion is expected because of too many buses arriving and departing. Therefore, it will be eventually necessary to introduce a new public transport system with greater capacity than the existing one.

12.3.1 Classification of Urban Transport System

Table 12-3-1 shows capacities of various urban transport systems, and Table 12-3-2 their construction costs. The maximum number of passengers on Av. E. Ayala is 309,000, and 15,450 passengers per hour on one side with the peak rate of 10%. Since it is likely that the existing bus lines are needed to meet short-distance travel demands, some of the lines will not be replaced with new ones. It makes economic sense, therefore, to introduce a system of trunk buses consisting of two sections. However, in response to an increase in future demand, it is necessary to consider possibilities of converting them into three-section trunk bus or subway.

Table 12-3-1 Maximum Transport Capacity of Urban Transport Systems

	Length	No. of Cars	Car Length	Capacity	Interval	Congestion rate	Transport Capacity
Linear Subway	16m	8	128m	100 per.	1 min	200%	96,000per/ hour
LRT	10m	3	30m	75 per.	1 min	150%	20,250per./ hour
Trunk Bus (3 Sections)	25m	1	25m	270 per.	1 min	150%	24,300per./ hour
Trunk Bus (2 Sections)	18m	1	18m	160 per.	1 min	150%	14,400per./ hour

Table 12-3-2 Construction Costs of Urban Transport Systems

	Linear Subway	LRT	Trunk Bus
Cost (in million US$/km)	200	<33	3

The greatest numbers of passengers per day on other trunk roads in 2015, Av. Mcal López, Av. España, Av. Fdo. de la Mora, and Av. Artigas, respectively, are 130,000, 142,000, 146,000, and 121,000. Multiplied by the peak rate of 10%, the numbers in a single direction are 6,500, 7,100, 7,300, and 6,050, respectively, which is less than the capacity of the trunk bus. However, assuming the number of passengers at peak hours is 40, the numbers of bus vehicles on each of the trunk roads is 162, 177, 183, 151, respectively, and exceeds the handling capacity of a bus stop and may obstruct flows of other traffic. Thus, it will be necessary to use larger-scale vehicles and secure priority or exclusive bus lanes.

12.3.2 Alternative Lines for Introduction of Trunk Bus Services

Assuming that two buses could simultaneously occupy one bus stop, the system could handle 240 buses per hour and 9,600 buses/day/section (=240x20x2), with a daily operation time of 20 hours. Bus lines predicted to exceed this capacity in 2005 are only the section on Av. E.

Ayala and Av. Mcal. Estigarribia. This road meets the following conditions and thus warrants the introduction of a trunk bus system in 2005.

1) Trunk road with more than four lanes except for Micro Centro:

This line has four to six lanes, and after taking exclusive lanes for the trunk bus, lanes can be provided for autos and other buses. In Centro, one of the two one-way lanes will be used for the trunk bus only.

2) Trunk road with a high concentration of the existing bus lines:

There are many existing bus lines that access Centro through Av. E. Ayala.

3) Route between two major centers and with high transport demand to connect them:

San Lorenzo and Centro are two major centers in the area, and there is large transport demand in between, which warrants linear bus services.

From these criteria, Av. E. Ayala has been selected as the first priority corridor to introduce the new transit system. In the 1988 study, the same concept was applied, and a bus terminal was planned near the Mercado 4 underneath the planned connection viaduct between Av. E. Ayala and Av. R. Francia. However, there seemed to be a difficulty with purchasing land for the bus terminal for many reasons. Therefore, this Study plans to introduce the new transit system as far as Colon, the western end of Micro Centro. The terminal in San Lorenzo is planned near the junction of National Routes 1 and 2.

The trunk bus route is shown in Fig. 12-3-1. The entire section extends for 16.1km. Table 12-3-3 shows requirements of the trunk bus system.

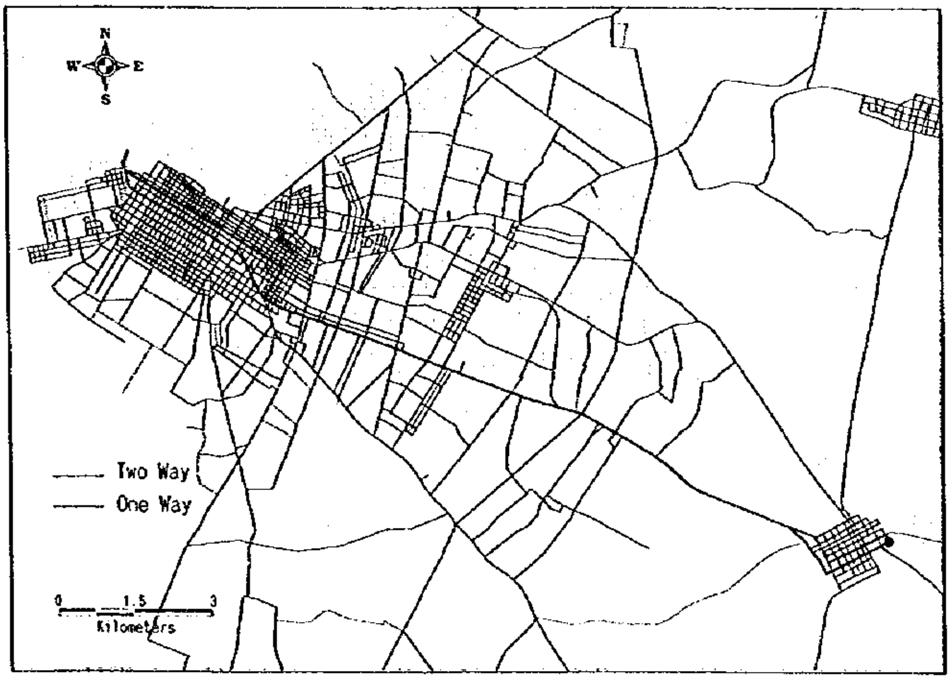

Fig. 12-3-1 Trunk Bus Route

Table 12-3-3 Requirements of Trunk Bus

Items	Requirements
Vehicle Capacity	Two-sections articulated bus. 160 passengers
Frequency	Minimum headway is one minute
Speed	The current bus speed is 23 km/h on average, and it is forecast to slow down to about 15km/h. For better performance than this, the new system is designed for 25 to 30km/h.
Operating Line	Exclusive lanes will be provided in the middle of the road beside median strip. Linear bus service will be provided between San Lorenzo and Centro.
Spacing between Bus Stops	1km on average. High-speed operation requires a longer spacing than the existing one. Between San Lorenzo and Mme. Lynch, it is planned to be longer. To increase the service level, in Asunción, the trunk bus stops at intersections with other trunk roads, and in Centro, it makes more frequent stops.
Bus Stop Facilities	Considering transfers to the existing lines, wide platforms are necessary. Good access to roadside facilities is needed as well.
Terminal	Built in San Lorenzo and Centro. The terminal in San Lorenzo needs to respond to demands for transfers to suburban lines. The Centro terminal will be small and have facilities for turning buses and time adjustments only.

12.3.3 Effects of Trunk Bus Service

From the logit-type disaggregate mode choice model in Chapter3.4.2, the conversion from auto to bus induced by the introduction of the trunk bus system has been computed and shown in Table 12-3-4. It is assumed that the trunk bus runs at 30km/h and receives renovation. From the same table, the trunk bus will facilitate the conversion, which amounts to 66,534 trips (3.0% of auto trips), or about 41,000 vehicles. In addition, with full renovation implemented, the number of conversion will be 180,617 trips (8.3% of car trips in do nothing case), or about 112,184 vehicles.

Table 12-3-4 Conversion Effects on Auto Trips by Trunk Bus

		1998	2015		
			Do nothing	Trunk Bus System only	Trunk Bus System + Renovation=50%
Car	(T.E)	1,138,960	2,182,261	2,115,727	2,001,644
	(Vehi.)	758,033	1,355,442	1,314,116	1,243,257
Car->Bus	(T.E)			66,534	180,617
	(Vehi.)			41,325	112,184
Bus	(T.E)	1,150,214	1,879,831	1,946,365	2,060,448
	(Vehi)	54,800	82,521	85,442	90,450

The number of vehicles is trips divided by the average number of passengers.
Car = 1.61 passengers/vehicle, Bus = 22.78 passengers/vehicle

Fig. 12-3-2 and Fig. 12-3-3 show bus passenger flow and bus frequencies in 2015 after the introduction of trunk bus services on Av. E. Ayala, respectively.

These Figures show that the number of passengers will be similar to that before the trunk bus service, or 310,000 in Av. Mcal. Estigarribia and Fdo. de la Mora, and 260,000 between Av. Chof de la Chaco and Av. Gral. Santos on Av. E. Ayala. Despite that, the number of bus vehicles on road will be less than half of that before, or 3,640 (including 1,500 trunk buses) in Fdo. de la Mora, and 4,370 (including 1,500 trunk buses) between Av. Chof de la Chaco and Av. Gral. Santos on Av. E. Ayala. Therefore, the introduction of the trunk bus will produce significant impacts on congestion alleviation.

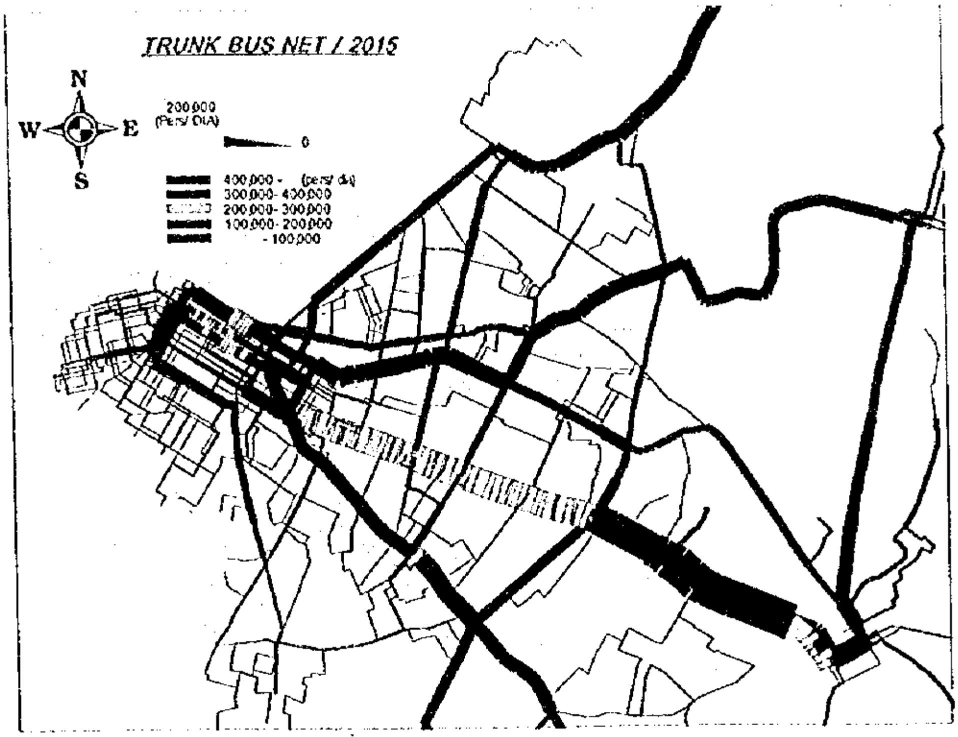

Fig. 12-3-2 Bus Passenger Flow in 2015

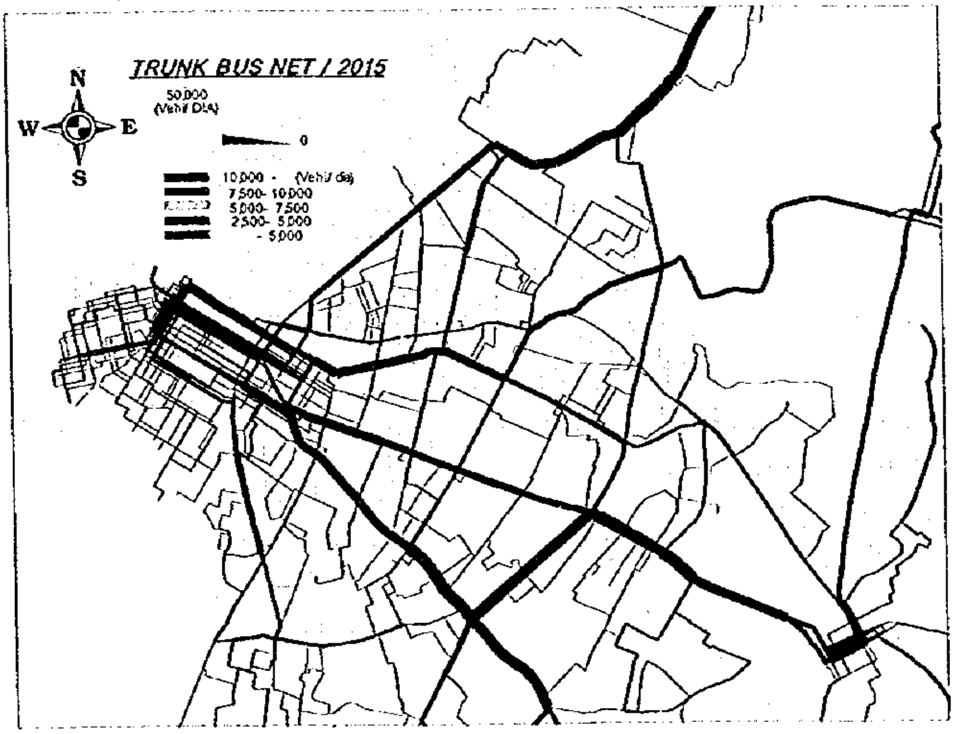

Fig. 12-3-3 Bus Frequency with Trunk Bus Service in 2015

12.4 Improvement of Bus Operating System

12.4.1 Principle of Bus Priority Policy

During the 14 years after the previous Master Plan Study in 1984, the population concentration in the metropolitan area has increased more rapidly than projected, and low-density urban sprawl has taken place. As a result, population has been growing in suburban cities more rapidly than in Asuncion. Shares of travel modes by those residents have changed, and the use of private vehicles surged from 39% in 1984 to 50% in 1998, which clearly signifies that rapid motorization has been taking place. If this tendency is left untouched, urban sprawl continues, and the metropolitan area accelerates its dependence on private vehicles. It is evident that trunk roads and Centro will be even more congested, and that environmental conditions will worsen.

Without policies that limit the use of private vehicles and prioritize public transport, travel speed of vehicles on trunk roads will be as slow as that of walking during peak hours in 2015, which inhibits efficient urban activities. Therefore, it is imperative to decide on transport policies now.

12.4.2 Improvement of Bus Service

(1) Comfortability Improvement

According to the result of the mode preference survey conducted by JICA Study Team, comfortableness is one of the most important factors to select public transport. It is necessary to improve the comfortableness of bus services in the Metropolitan Area.
There are two meanings of comfortableness. One is a type of physical conditions such as bus seats and bus facilities, and another type is man provided services such as driver's behavior.

1) Physical Improvement

It is necessary to improve the following points;

- Shelters of bus stops: Shelters of bus stops have been developed, but there is still lack of shelters at bus stops. Shelters should be developed with collaboration of private sectors.
- Bus seats and interior: Since present bus seats and interior are not comfortable for passengers, they should be improved.
- Noise, Vibration and exhaust gas: Because of old vehicles and bad maintenance, noise, vibration and exhaust gas make the service inconvenient for passengers. It is necessary to introduce stricter vehicle inspection system for environmental improvement.

2) Service Improvement

- Bus drivers' behavior: Since salaries of bus drivers usually depend on how many round trips they make, they tend to drive buses very roughly. The education of drivers should be developed and improvement of the remuneration system should be made.
- Safety and security: The existing traffic accidents involving buses are relatively many and they are related to bus driver behavior. Traffic safety programs should be extended.
- Information announcement such as timetables: There exists no information on routes and schedules of buses at bus stops. This kind of information should be provided

(2) Minimum Guaranty

Since public transport is one of the most important urban services, minimum level of services should be supplied for daily urban activities.

- Access distance to bus routes: Within the Asuncion municipal area, all areas are almost covered by bus routes, but in other cities many areas do not have close access to bus routes. In the built up areas, bus routes should be provided with 1 Km access.
- Operating hours
  Bus operating hours in the Study Area is relatively long compared with the buses in other capital cities in Latin America, but for urban activities, prolonged operating hours is requested

(3) User Oriented

The government and bus operators should change their idea and consider always what bus users request from bus service. The following points should be checked in order to attract people to public transport.

- Route location
- Frequency
- Travel velocity
- Transfer function

(4) Tariff Level

There are no opportunities for citizens to participate in the process of decision making of tariff level. Tariff level should be decided considering not only the information of operators but also information from the people using the service.

12.4.3 Restructure of Bus Operation System

(1) Integration of Operators

In the metropolitan area there exists 61 companies and 118 routes. In general, bus companies are small in scale and have more than one owner.

Many bus lines originate in the suburbs and pass along their own routes, but on entering Asuncion, they concentrate on trunk roads. Service frequencies are very high and thus convenient for users on trunk roads, but they are scarce and unreliable on local roads. In other words, a single line often needs to serve both trunk and local bus functions.
The extension of bus routes is inevitably long and complex. Some of the routes include unpaved roads as well. As described above, the transport efficiency is low on trunk roads, and the operation of bus companies is generally inefficient as well.

That is the reason why bus companies should be integrated to rearrange bus routes and the number of buses.

(2) Tariff System

- The present fare is mainly a flat fare system, Gs850, within the Metropolitan Area, but it is higher in San Antonio, Limpio, Villa Hayes, Gs900, Gs1,000, Gs 1,700, respectively.

- Passengers pay fares to the driver in entering the bus from the front door. They pay in cash, and the driver gives them a ticket. Passengers get off from the rear door. Bus drivers report sales of the tickets to their companies. This is basic operational data.

- Tickets serve as some type of receipts for each bus, rather than for the entire company. There are neither common tickets nor passes for a certain time period. There are no student discounts, either.

- In order to slow down the process of moving toward a motorized society and increase the attractiveness of public transportation, it is necessary to simplify the fare structure and make it user-friendly.

- Although it is necessary to restructure or integrate bus routes for efficient operation, the current fare system is the obstacle to it, and radical reform is called for.

- The introduction of a hierarchical route system and the separation of trunk lines from feeders will not be a problem for bus users if they are allowed to transfer with low costs.

- The introduction of common tickets can allow passengers to transfer.

- The introduction of common tickets requires a uniform fare system or a system with large fare zone

12.4.4 Institutional Reform

(1) Necessity of Coordination of Institution

There are two institutes related to bus administration. Municipalities provide licenses to bus operators within one municipality and MOPC gives licenses to operators which operate in plural municipalities. The contents of the regulations are not clear and are complicated. There is a lack of coordination between MOPC and a municipality and among municipalities. There exist some cases that operators operate bus routes in several municipalities without appropriate licenses.
In order to change this kind of situation, coordination among the different institutes is urgently required.

(2) Subsidies

1) Principle of the subsidy policy

There are many kinds of negative opinions on subsidy introduction such as;
- Subsidy causes inefficient management of bus operation.
- Subsidy creates the necessity for more subsidies.
- Subsidy does not reach final users.

However, in order to realize the public transport priority policy, the central government and the local governments should contribute some part of the cost of the projects and this means this use of is subsidies.

The principle of subsidy should be the follows;

- The subsidy should reach directly beneficiaries (bus users).
- To develop the infrastructure supporting public transport development

2) Principles of Financial Resources

The objectives of the project are to attract people to public transport and to limit use of private car use. One principal financial resource would be to levy a charge from private car users to make a contribution for the project. Another financial resource will be to ask beneficiaries of the development of the project such as commercial companies along the trunk bus way.

(3) Necessity of Institution Reform

The introduction of the trunk bus system requires revisions of the existing institutions, such as relevant laws and organizations. Now the new surface transportation system law under discussion in parliament is waited for passed soon. First, it is necessary to establish an organization that plans, promotes, regulates, and supervises the project. It is also recommendable to establish an organization like a public corporation or public-private entity, if necessary, for construction and operation of the project. Moreover, securing funding sources requires some revisions of the laws and regulations.

Finally, it is strongly recommended to create an organization that can plan, coordinate, implement, and monitor urban transportation in the metropolitan area from a comprehensive standpoint.

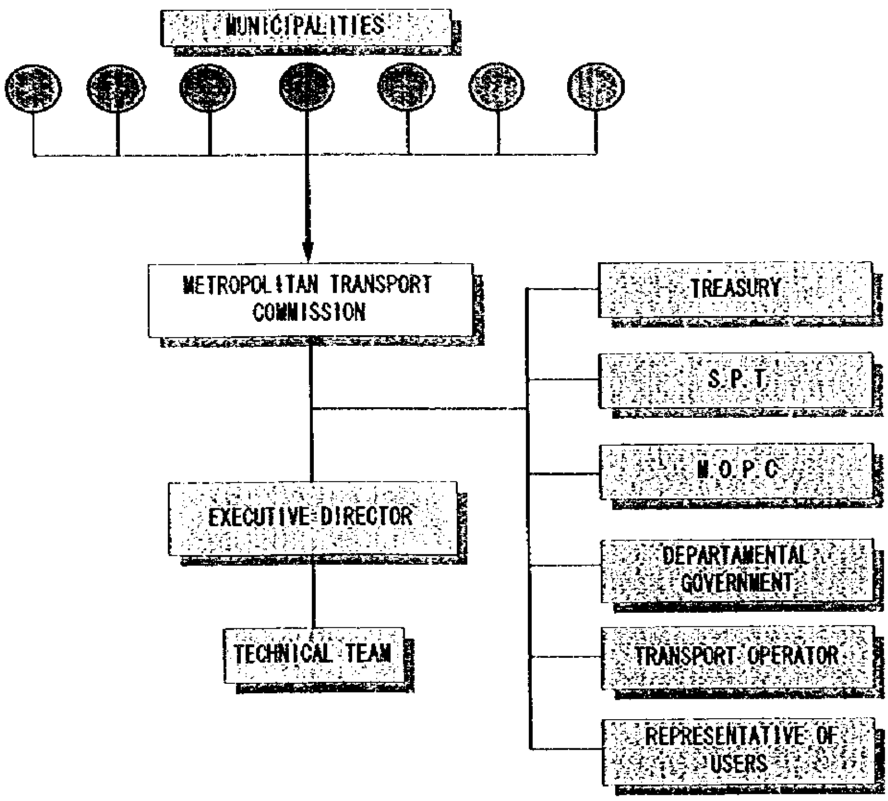

Fig. 12-4-1 Schematic Chart of Organization for Metropolitan Transport

Chapter 13 Road Network Plan

13.1 Issues on Road Network

Issues on road traffic can be summarized as follows:

- Trunk roads consist of two- and four-lane sections, and traffic does not flow smoothly from a two-lane to a four-lane section, or vice versa.
- Trunk roads do not have full control of access, which reduces their traffic capacities.
- Traffic functions are actually determined by surface conditions, and much traffic including through traffic attempts to use paved roads. There are no clear differences between collectors and local roads. This lack of a hierarchical road system ends up encouraging through traffic to flow on paved roads parallel to congested trunk roads, which worsens the living environment of residential areas.
- Empederad is used as the base course for the asphalt paved roads. There are damages to the surface layer caused by the subsidence or washout of the base course materials after completion. Abolished tram tracks exist on some roads, which make it difficult to operate vehicles.
- There are few storm water drainage systems along roads, and inundation often significantly paralyzes traffic functions of the road.
- If nothing is done about the current traffic problems, traffic flow and travel time in 2015 will be worsened as shown in Fig.13-1-1 and Fig.13-1-2, respectively. Fig.13-1-3 illustrates changes in travel time between the cities in the metropolitan area. In particular, traffic functions in the north-south direction will be significantly reduced, such as on the section between Luque and San Lorenzo.

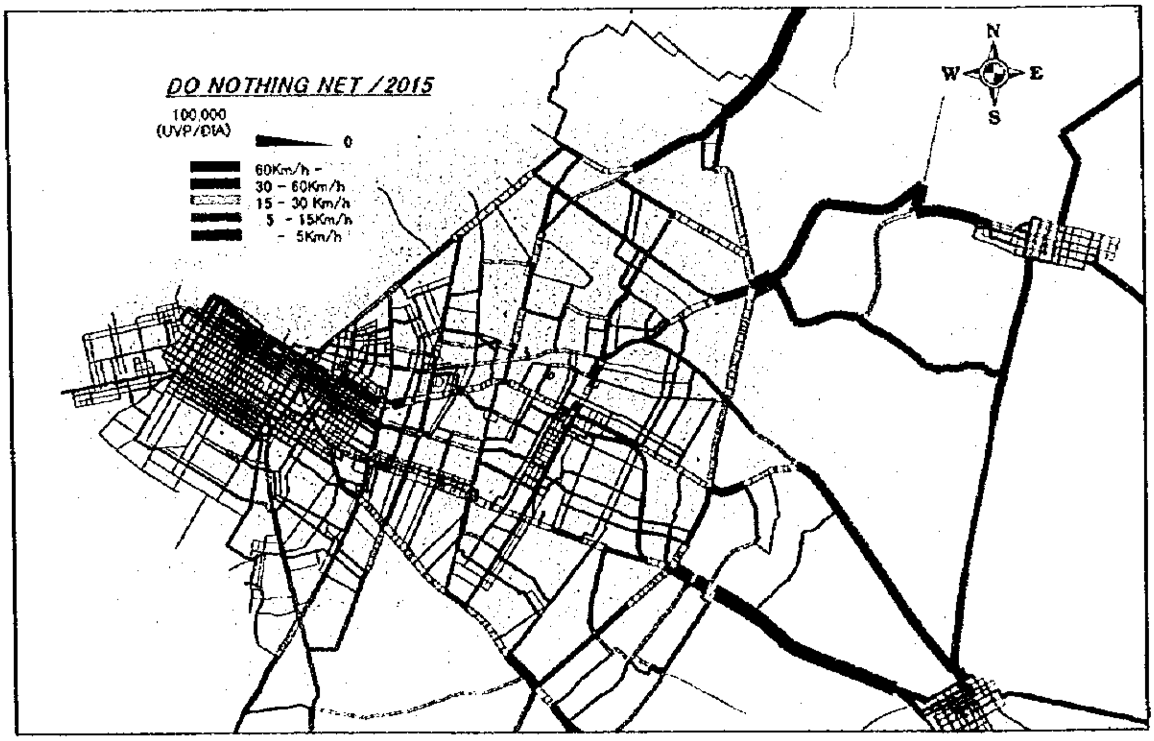

Fig.13-1-1 Traffic Flow in 2015 under Do-nothing Case

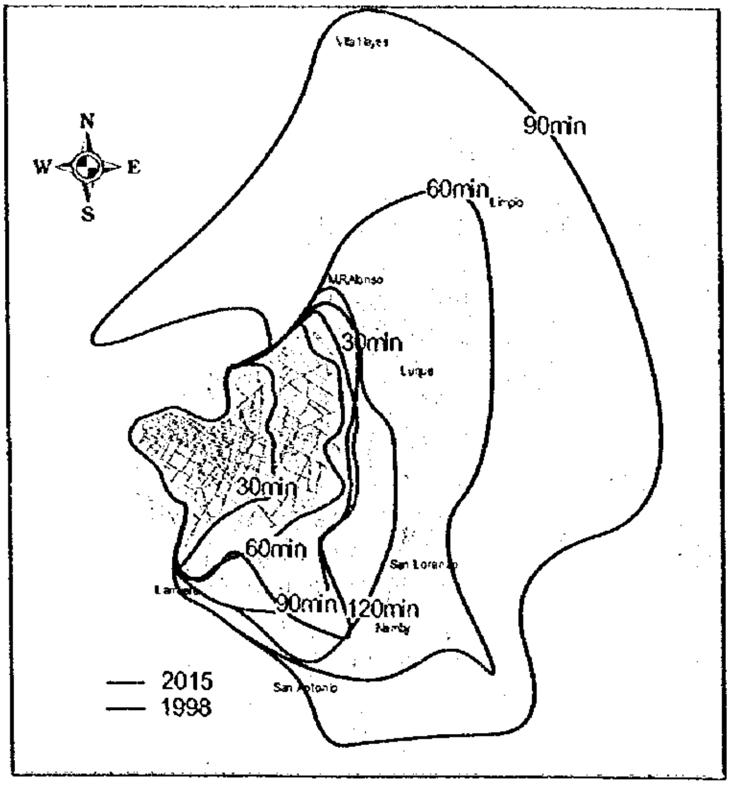

Fig. 13-1-2 Travel Time from Micro Centro in 2015

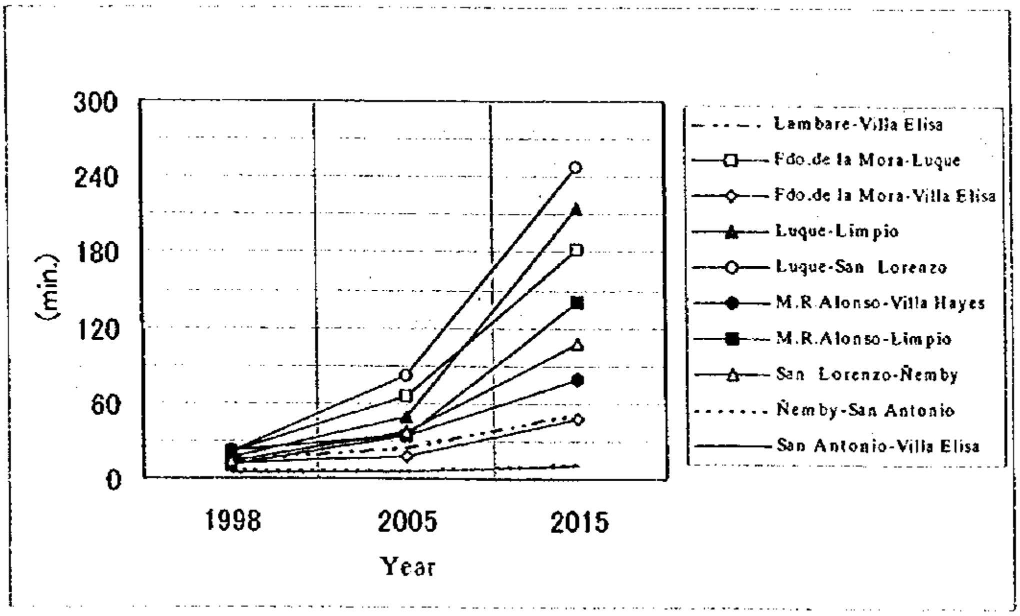

Fig. 13-1-3 Travel Time between Cities

13.2 Basic Policy

Basic policies on road development are described below.

(1) Road Development to Lead the Proper Land Use

Road development should basically support land use. The land use plan in the Study has decided to pursue a strategic corridor development as the most desirable land use pattern in the Asunción metropolitan area with development axes on Av. E. Ayala and Av. Mcal. López. Small-scale commercial areas are located along Av. E. Ayala at present but will be replaced by larger-scale commercial and business establishments in future to form major commercial axes in Asunción. The Avenue should be improved to accommodate heavy traffic to support commercial activities. In addition, the municipalities in the metropolitan area should be directly connected with each other within an improved road network to form an integrated economic region.

(2) Road Development to Support Public Transport Use

In order to encourage public transport use, development of roads with many bus services should be planned, giving priority to bus operation. Especially, on Av. E. Ayala, which will be the main corridor of the public transport after the introduction of trunk bus services, it will be inevitable to construct exclusive bus lanes in order to maintain adequate travel speed.

Other trunk roads without trunk bus services should reserve spaces for bus priority lane and/or bus bays. In particular, since public transport axes including the trunk bus will cross the Micro Centro, private vehicles should avoid running on the same roads with them. For this, their accesses to the Centro should be directed from either the north or the south, and their flows should be channeled into axes that run around the edge of the Centro.

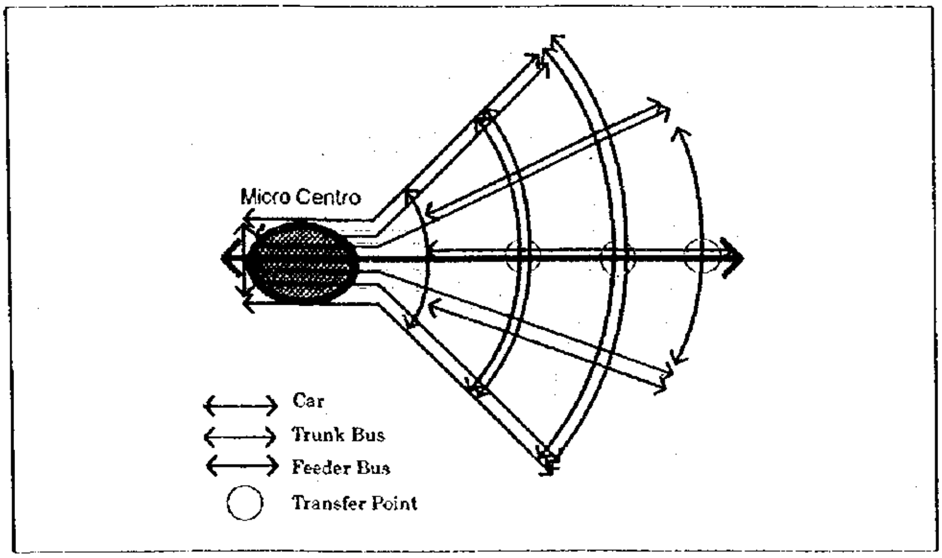

Fig.13-2-1 Image of Transport Axes

(3) Establishment of Road Hierarchy

Roads in Asunción form a grid network with spacing between each of about 100m. Traffic often flows into paved roads parallel to congested trunk roads, which negatively affects the living environment of residential areas. To improve the environment in the residential areas, it is necessary to establish a road hierarchy system that classifies roads as trunk, collector, or local. Trunk roads should have more than four lanes and be given an importance for increasing traffic capacity by installing median strips to limit crossing traffic. They should be planned with a spacing of about 1 to 2km. Collectors, on the other hand, should have the function to supplement the trunk road network by providing local traffic access to trunk roads. Collectors should be allocated with a spacing of about 500m to 1km. Local roads should serve only local traffic and should not allow buses to use them, for there are many pedestrians and on-street parking. The installation of dead ends (*romadas*) or "cue de sac" should be considered in planning local roads to limit through traffic. The concept of the road hierarchy is shown in Fig.13-2-2.

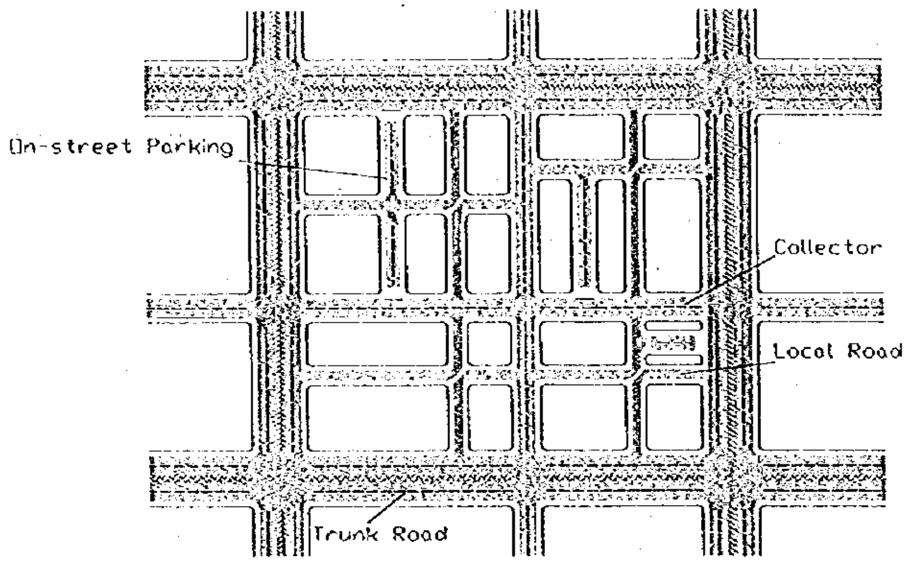

Fig.13-2-2 The Concept of Road Hierarchy

(4) Improvement of Pedestrian Environment in Micro Centro

Public transport should be given a higher priority to access Micro Centro, and access by private vehicles should be limited. Thus, facilities to encourage public transport use and pedestrian traffic, such as widening of sidewalks and vegetation, should be provided instead of facilities for cars.

(5) Road Development based on Public Funds

Most of the recent road improvements in Asunción have been carried out by the Frentista system. The system has an advantage that road improvements are made at locations where they are needed, but they are often not planned well. The improvement of trunk roads and collectors should be implemented by initiatives based on available public funds. The system can be applied to the improvement of local roads to install traffic calming devices, such as *romadas*, to keep through traffic away from residential areas.

13.3 Proposed Road Projects

13.3.1 Proposed Projects of Trunk Roads

As shown in Fig.13-3-1, those areas that will be urbanized in future are Asunción, Fdo. de la Mora, and an area between Av. Mcal López and Av. Fdo. de la Mora in San Lorenzo. In these areas, studies will be conducted to examine projects to construct trunk roads with spacing of 2km. Trunk roads should have more than four lanes.

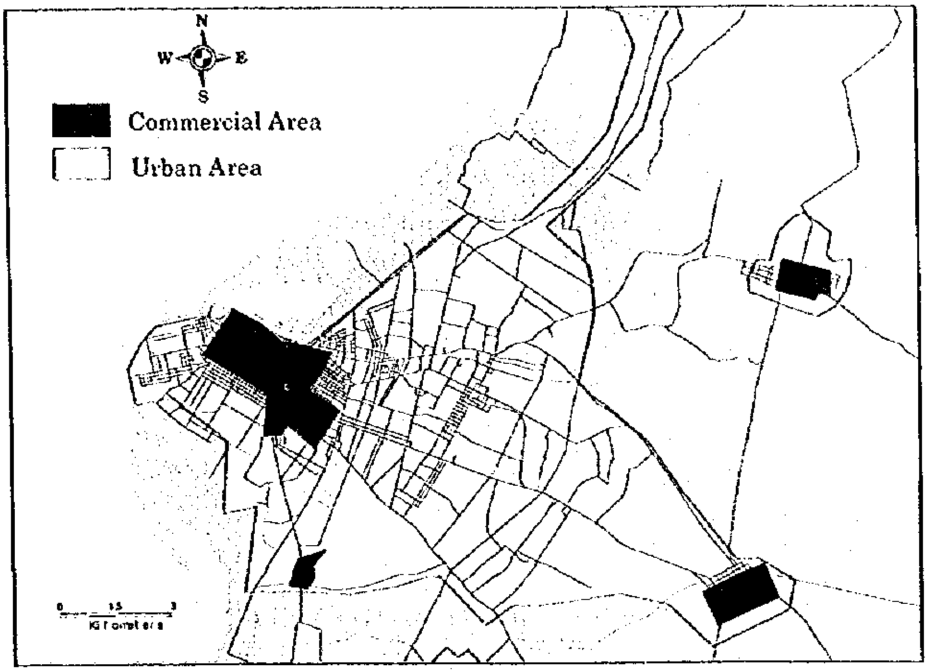

Fig.13-3-1 Urbanized Areas of Asunción

There are five axes of radial trunk roads to be considered in the Study: from the north, Av. Artigas, Av Mcal López, Av. E. Ayala, Av. Fdo. de la Mora, Av. J. F. Bogado. Since Av. España has only two lanes, and it is difficult to widen it, it has been excluded from project candidates for trunk roads. Ring roads are, from the center, Av. Peru, Av. Gral Santos, Av. Chof. Chaco, Av. R. Argentina, De la Victoria - Pitiantua, Av. Mme. Lynch, and Tte. Ettienne - Ricachuelo - Ytroro - Gral. Elozardo and Aquino - Av. Nanawa between Fdo. de la Mora and San Lorenzo. Two-lane sections of these roads will be added with two more lanes. In Asunción, many of them are already designated as four-lane roads by ordinance.

This development plan still leaves the northern part less dense in terms of road network. Thus, Julio Correa-Tte. 2do M. Pino Gonzalez that connects to San Martin-Av. M. Bogarin will be four-lane roads and connected to Mme Lynch. East-west roads will be paved, widened, and connected, and a mini-bypass will be built for Av. España.

As a southern axis into Micro Centro, Av. Ytá Ybaté will be developed into a paved four-lane road. As a northern access, a trunk road will be provided from the intersection of Av. Artigas and Av. España to the center of Micro Centro along the riverside of Av. España.

Fig.13-3-2 shows a balance of traffic demand and supply at each section in the "do-nothing" case. It indicates that there is a lack of traffic capacity along the riverside in the north. In order to resolve this situation, Paseo Constanero will be connected to Colon in Centro from Mme Lynch along the riverside. It will be developed as a trunk road with four to six lanes.

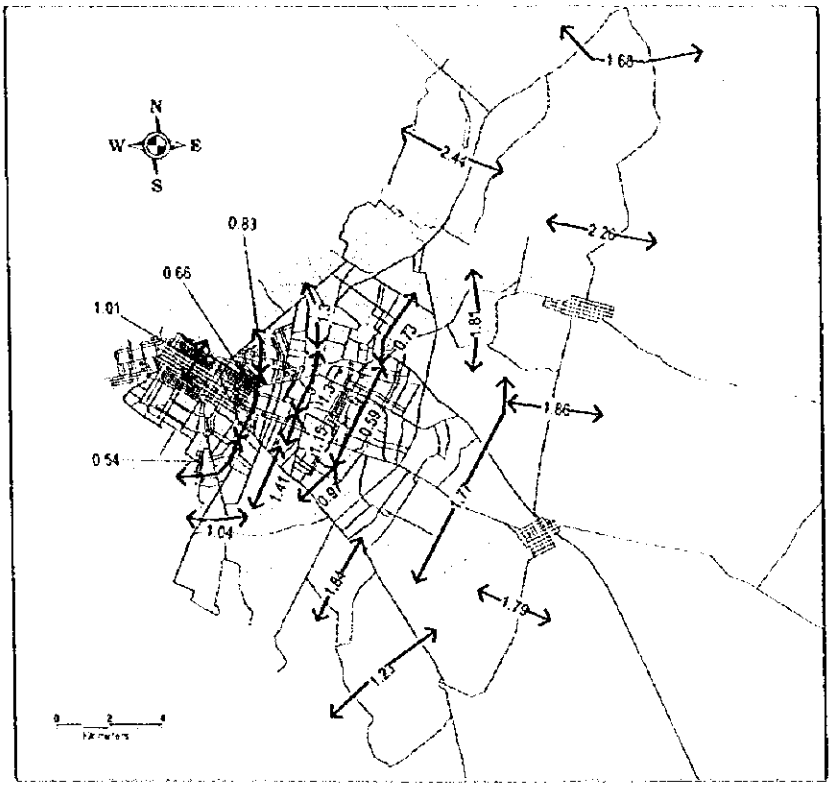

Fig.13-3-2 Congestion Rate on Sections (Do Nothing Case in 2015)

In order to support public transport, Av. E. Ayala will be developed into a six-lane road, and viaducts will be provided at intersections with trunk roads so that congestion at the intersections can be minimized.

These proposed road projects described above are summarized in Fig.13-3-3 and Table 13-3-1.

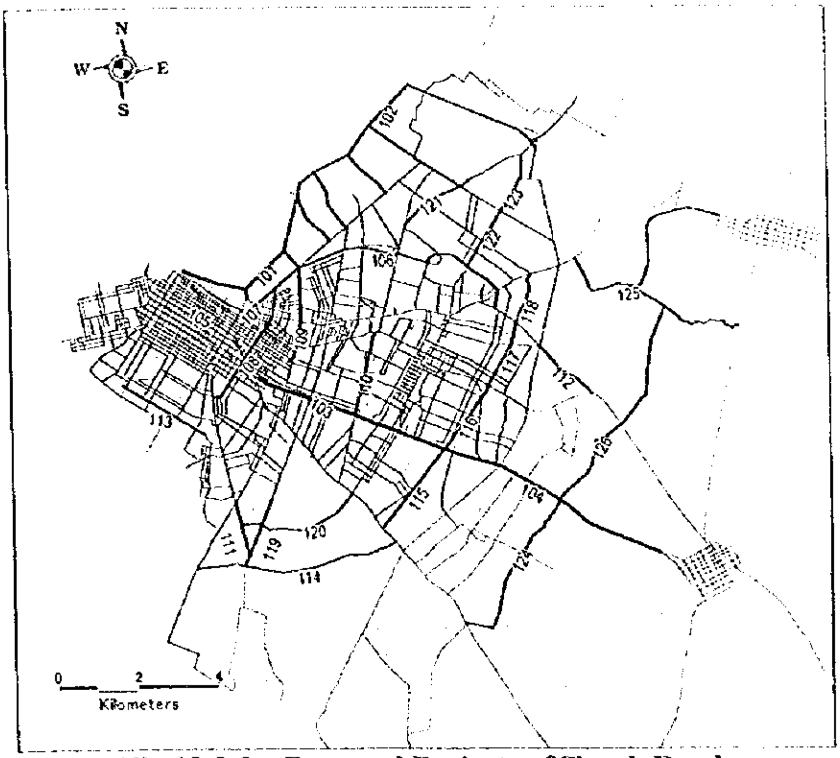

Fig.13-3-3 Proposed Projects of Trunk Roads

Table 13-3-1 Improvement Projects of Trunk Roads

Number	Name		Lanes	Length(km)
101	Paseo Costanero Norte		6	4.88
102	Paseo Costanero Norte		4	16.32
103	Av.Eusebio Ayala(General Aquino-Calle Ultima)	Widening	6	6.45
		Viaduct (Kubitsheck)		
		Viaduct (Chof. De la Chaco)		
		Viaduct (Rca. Argentina)		
		Viaduct (De la Victoria)		
104	Av.Eusebio Ayala(Calle Ultima-San Lorenzo)	Improvement	6	4.54
105	Av.Eapaña	Extension	4	0.65
106	Av.Eapaña-Desvío	Widening	4	6.01
		Viaduct(Railway1)		
107	Av.Artigas	Widening	4	1.68
108	Av.Perú	Widening	4	3.28
109	Av.Gral Santos	Widening	4	2.41
110	Av. Chef. del Chaco	Widening	4	2.09
111	Av. J. F. Bogado(1ro. de Marzo)	Widening	4	1.65
112	Av. Sta. Teresa	Widening	4	1.75
113	Av.Itá Ybaté	Pavement	4	3.22
114	Casique Lambaré	Widening	4	5.23
115	De la Victoria	Widening	4	2.54
116	Pitanluta	Widening	4	1.92
117	Bernardino Caballero	Widening	4	1.70
118	Mayor Merlo	Widening	4	1.33
119	Av. Bruno Guggiari	Widening	4	1.62
120	Rca. Agrentina	Widening	4	3.22
121	Gral. Rafael Franco	Widening	4	2.04
122	Julio Corréa	Widening/Extension	4	1.61
123	Tte.2do M.Pino Gonzalez	Widening	4	0.99
124	Tte.Ettienne-Riachuelo-Ytororo	Widening	4	7.00
125	Gral.Elozardo Aquino/Av.Nanawa	Widening	4	8.73
126	Av, Ita Ybate(Luque)-F.Salomon(SanLorenz)	Widening	4	3.28

13.3.2 Proposed Projects of Collector Roads

Collector roads supplement the trunk road network and will be developed more densely. One of their main functions is to collect and distribute traffic in a relatively small area but also handling traffic when trunk roads are not sufficient. In the north-south direction, circular trunk roads will be provided at 1.0 to 1.5km apart from each other. However, since in the east-west direction, spacing between radial trunk roads will be over 2km, the east-west direction will need to be strengthened by collector roads.

An east-west collector road will be provided in between Av. Mcal López and Av. E. Ayala, connecting Fdo. de la Mora and Av. Gral Santos (201-204 in Table 13-3-2). Likewise, another collector road will be developed in between Av. E. Ayala and Av. Fdo. de la Mora, connecting Fdo. de la Mora and Av. Gral Santos (205-209). Finally, two collector roads south of Av. Fdo. de la Mora will be developed, one from Fdo. de la Mora to Av. Tte Gral Peron (210-212) and the other from Lambaré to Av. Fdo. de la Mora (213-215). Av. Graldev Division M. Britez north of Av. Mcal López will be paved and connected to Mme. Lynch (213).

Circular collector roads will be developed in urbanized areas outside Asunción. Paseo de Fatima and Av. 3 de Febrero will be connected to planning paved roads in M. R. Aronzo and have direct accesses into Asunción. These roads will supplement Ruta Trans Chaco for its lack of traffic capacity. Projects of collector roads are summarized in Table 13-3-2 and Fig.13-3-4, and their total length amounts to 43.83km.

Table 13-3-2 Improvement Projects of Sub-Trunk Roads

Number	Name		Lanes	Length(km)	
201	Les Residantas	Pavement/Connection	2	1.59	
202	Avelino Martinez	Pavement	2	1.11	
203	Arterias secundarias	Connection	2	0.27	
204	Arterias secundarias	Connection	2	0.14	3.11
205	Avelino Martinez - Calle Ultima	Pavement	2	5.05	
206	Calle Ultima - De la Victoria	Pavement	2	1.11	
207	Arterias secundarias	Pavement/Connection	2	0.77	
208	Arterias secundarias	Pavement/Connection	2	0.55	
209	Arterias secundarias	Pavement	2	0.09	7.57
210	Fdo.de la Mora - Av. Def. del Chaco	Pavement/Connection	2	2.44	
211	Arterias secundarias	Pavement	2	1.44	
212	Defensor del Chaco	Pavement/Connection	2	3.70	7.58
213	Arterias secundarias	Pavement	2	1.44	
214	Arterias secundarias	Pavement	2	2.16	
215	Arterias secundarias	Pavement	2	0.96	4.56
216	Av.Gra de Division Mnuel Britez	Pavement	2	4.92	4.92
217	Autopista - Av.Mcal Lopez	Pavement/Connection	2	2.80	
218	Mcal. Francisco Solano Lopez	Pavement/Connection	2	1.07	3.87
219	Avelino Martinez	Pavement	2	5.71	5.71
220	Av.San Isidro	Pavement	2	2.68	2.68
221	Paseo de Fatima	Pavement	2	0.77	
222	Av. 3 Defebrero	Pavement	2	3.06	3.83
				Total	43.83

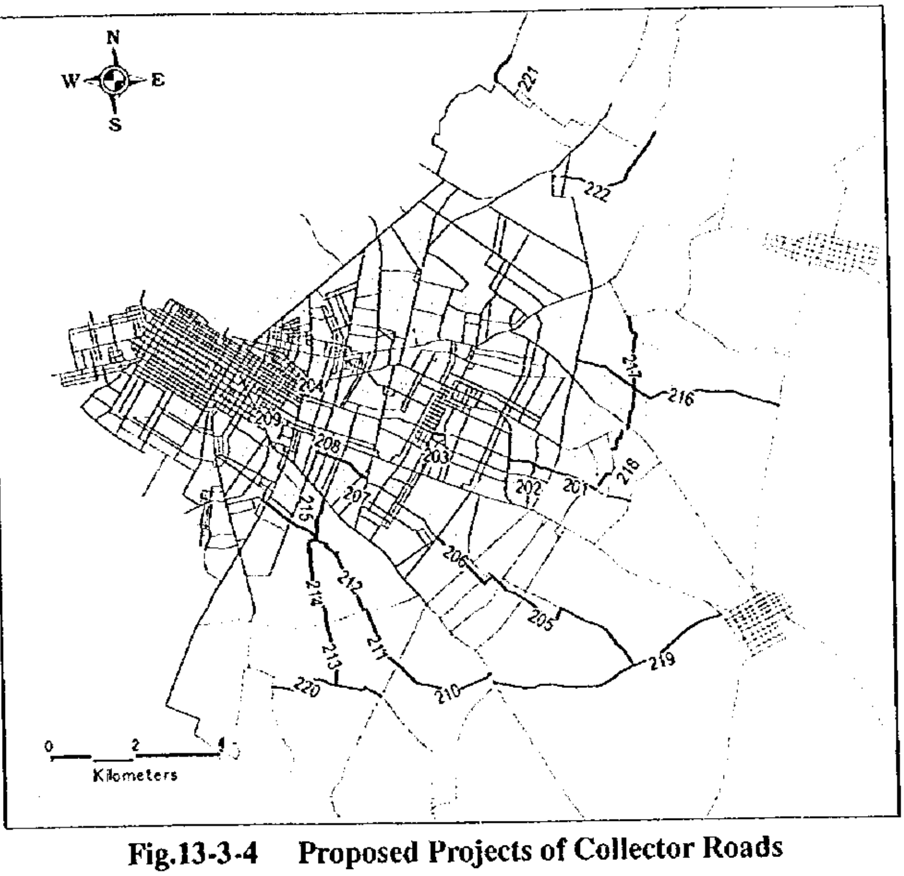

Fig.13-3-4 Proposed Projects of Collector Roads

13.3.3 Proposed Projects of Inter-city Roads

Inter-city roads will be widened and developed into four- to six-lane roads in order to reduce congestion and travel time between cities. A bypass will be provided for Routes 1 and 2 passing through the central district of San Lorenzo. The bypass starts at a point to the west of the central district of Capiata, crosses Route 1, and connects with Avelino Martinez. This project is necessary because there are many trips from Capiata into Asunción, and there are no adequate access roads to Asunción in the north of Av. Mcal López. Table 13-3-3 and Fig.13-3-5 summarize projects of inter-city roads. In sum, Fig.13-3-6 shows the major road network in Asunción consisting of trunk, sub-trunk, and inter-city roads.

Tbale 13-3-3 Communication Roads between the City

Number	Name		Lanes	Length(km)
301	Ruta 2 (San Lorenzo)	Detour	4	2.66
302	Ruta 1(San Lorenzo)	Detour	4	8.62
303	Ruta Nemby - San Antonio		2	6.37
304	San Antonio - Villa Elisa		2	4.86
305	Villa Elisa - Lambaré		2	2.49
306	M.R.Alonzo - Luque		4	7.47
307	Acceso a Aeropuerto		2	3.62
308	Luque-San Lorenzo	Widening	4	7.79
309	San lorenzo -Nemby	Widening	4	6.84
310	Luque-Limpio	Widening	4	10.98
311	Ruta Trans Chaco	Widening	6	7.45
312	Ruta 3(Limpio-M.R.Alonso)	Widening	4	6.54
313	Autopista Desvío(Luque-Mme.Lynch)		4	5.43

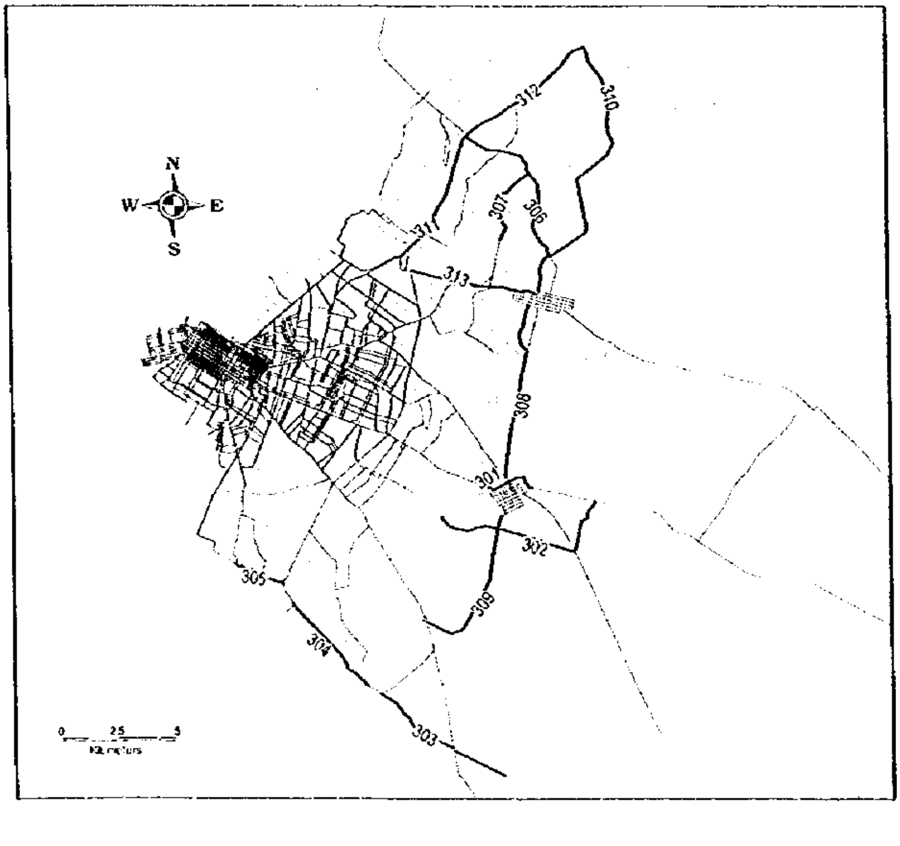

Fig.13-3-5 Proposed Inter-City Roads

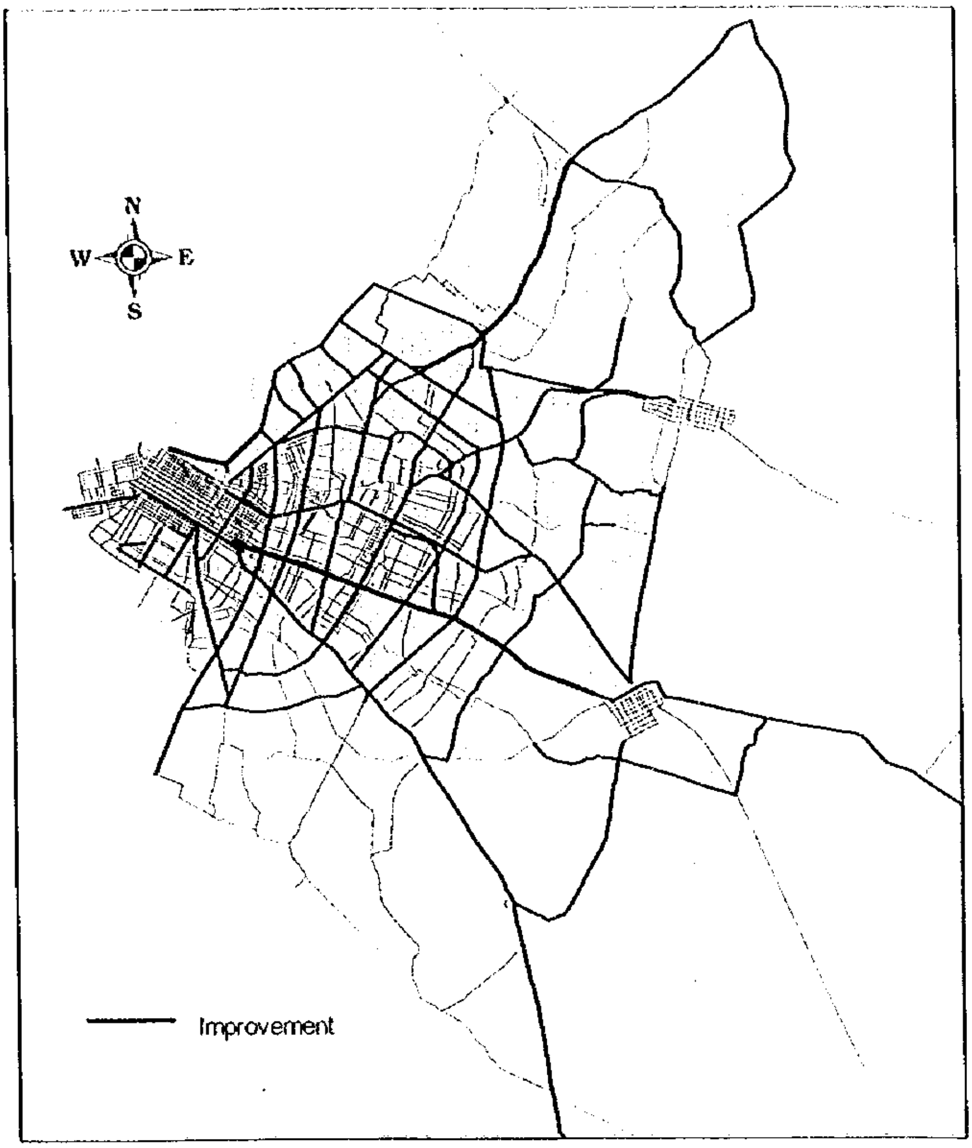

Fig. 13-3-6 Proposed Road Network in the Asunción Metropolitan Area

13.3.4 Proposed Projects of Intersection Improvements

Intersections will be improved where traffic congestion and accidents frequently occur.

Table 13-3-4 Intersection Improvements

Number	Name		Lanes
401	Av.Eusebio Ayala / Av. Rca. Argentina		4(6)x4
402	Av.Eusebio Ayala / Av. Chef. del Chaco		4(6)x4
403	Av.Eusebio Ayala / De La Victoria		4(6)X2
404	Av.Eusebio Ayala / Bartolomé de las Casas		4(6)x2
405	Av.Mcal. López / Av. Chef del Chaco		4x4
406	Av.Mcal. López / Venezuela		4x2
407	Av.Mcal. López / Av. Kubitchscek		4x4
408	Av.Mcal. López / Av. Gral. Santos		4x4
409	Av.Mcal. López / Av. Perú		4x2(4)

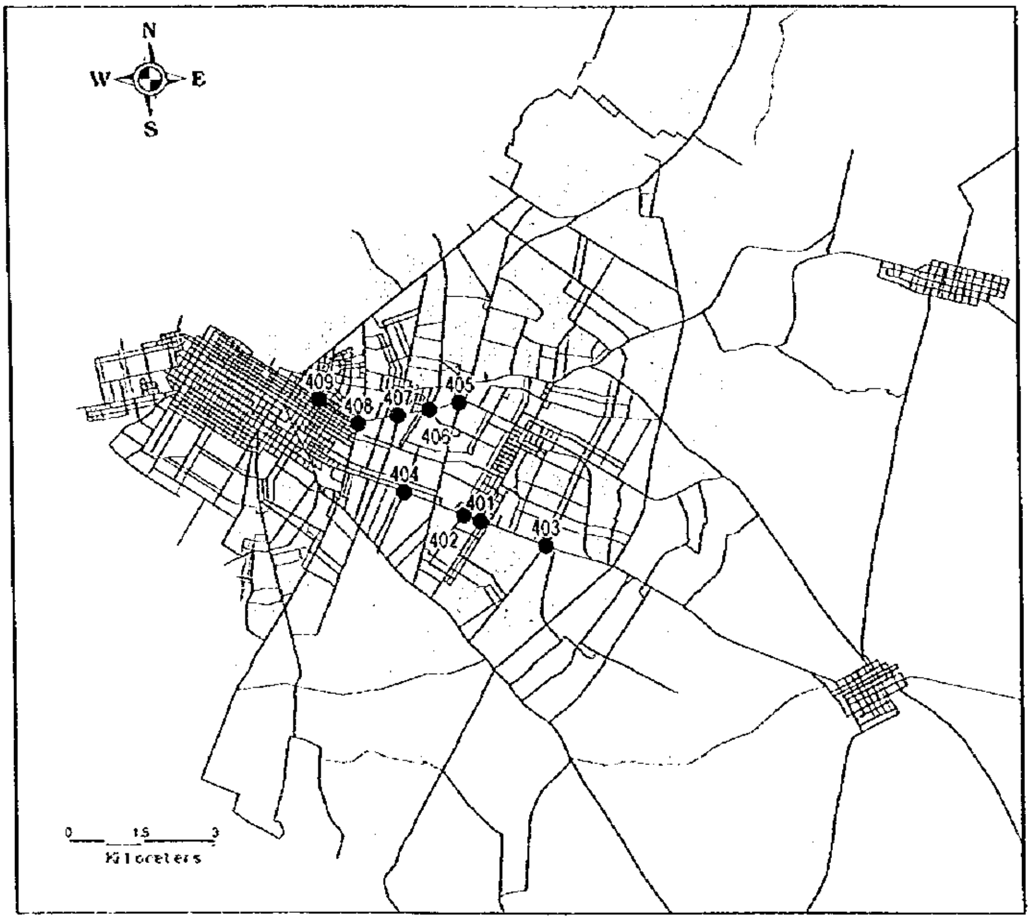

Fig. 13-3-7 Proposed Intersection Improvement Projects

13.3.5 Proposed Projects of Road Drainage Improvements

Improvements will be made on sections with serious drainage problems. Table 13-3-5 and Fig.13-3-8 show such improvement projects.

Table 13-3-5 Improvement Road Drainage Facilities

Number	Name	Lanes	Length(km)	
501	Av.Fdo. de la Mora / Bartolomé de las Casas	4X2		–
502	Av.Fdo. de la Mora / From Kubitscheck to Gral.Santos	4		1.61
503	Av.Fdo. de la Mora / San Martin	4x4		–
504	Av.Eusebio Ayala (General Aguino - San Lovenzo)	6		10.99
505	Av.Mcal. López / Sta.Rosa	4x4		–
506	Av.Mcal. López / Av.Chef. Del Chaco	4x4		–
507	Av.Mcal. López / Gnal. Garay	4x2		--
508	Av.Mcal. López / Av. San Martin	4x4		–
509	Av.Mcal. López / Bernardino Caballero	4x2		--
510	Av.España / From Kubitscheck to Sacramento	2(4)		1.36
511	Av.Artigas / Av. Gral Santos	4x2(4)		–
512	1er.Presidene / From Artigas to Transchaco	4		0.81
513	Av.Aiadores del Chaco	4		1.16

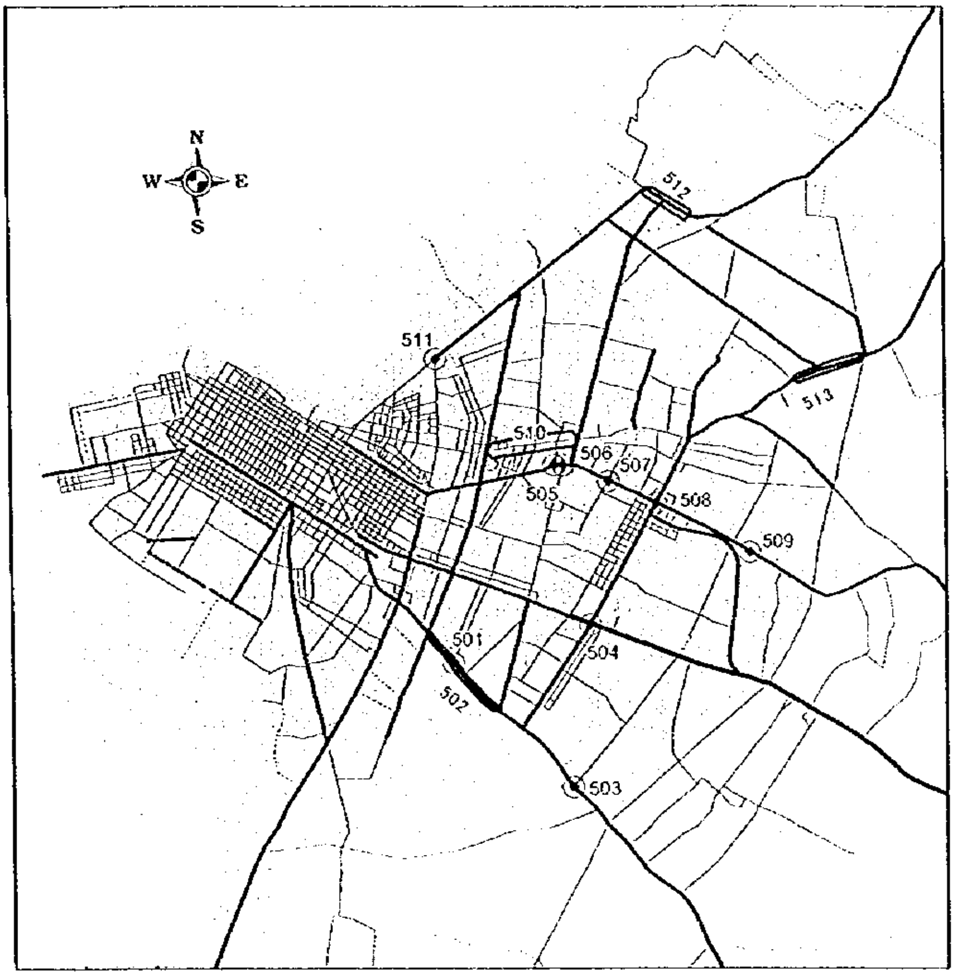

Fig.13-3-8 Proposed Projects of Road Drainage Facilities

13.4 Cost Estimate

13.4.1 Determination of Unit Cost for Cost Estimation

Unit costs used for the cost estimation of the following projects, which are included in the Master Plan with a target year of 2015 and higher priority projects for the Feasibility Study with a target year of 2005, have been determined;

1. New road construction
2. Widening of existing roads
3. Improvement of intersections
4. Improvement of drainage facilities

(1) Determination of unit costs for new road construction

Unit costs for new road construction have been determined with reference to the unit cost used in the "The Feasibility Study on Arterial Road Development Project in the Central Eastern Area in the Republic of Paraguay" (hereinafter referred as "Central Eastern Area Study") carried out by JICA, since its cost estimation is one of the latest cost estimations for a new road construction project, even though target roads in its study are under the jurisdiction of MOPC. In addition, unit cost for the new road construction consists of earthwork cost, pavement cost, and land acquisition cost, because most of newly proposed road sections require only earth works.

1) Unit Cost of Earthwork

Unit cost of earthwork is estimated with reference to unit cost estimated in the "Central Eastern Area Study", where sectional configuration of earthwork section (total length of 52.85km) was 2-lanes, carriageway width of 7.0m (2@3.5m), shoulder width of 2.5m for each side, and the total roadway width of 12.0m. Under this condition, the total earthwork cost was estimated as US$8,010,819 (in 1996 price and foreign exchange rate of US$1=Gs.2,020). Hence, unit cost of earthwork per kilometer for 12.0m roadway width section is estimated as US$102 thousand (in 1999 price and foreign exchange rate of US$1=Gs.3,000):

US$8,010,819 X 0.67 = US$5,367,250
(2,020/3,000=0.67: conversion of total cost in 1999 price)
US$5,367,250 / 52.85km = US$102,000 (unit earthwork cost per kilometer in 1999 price)

In this study, typical cross section is determined as illustrated in Fig 13-4-1, while cross sectional elements are determined as follows:

As a result, unit costs of earthwork for 2-lanes section (16.0m width) and 4-lane section (23.0m width) are estimated as US$136 thousand and US$196 thousand, respectively.

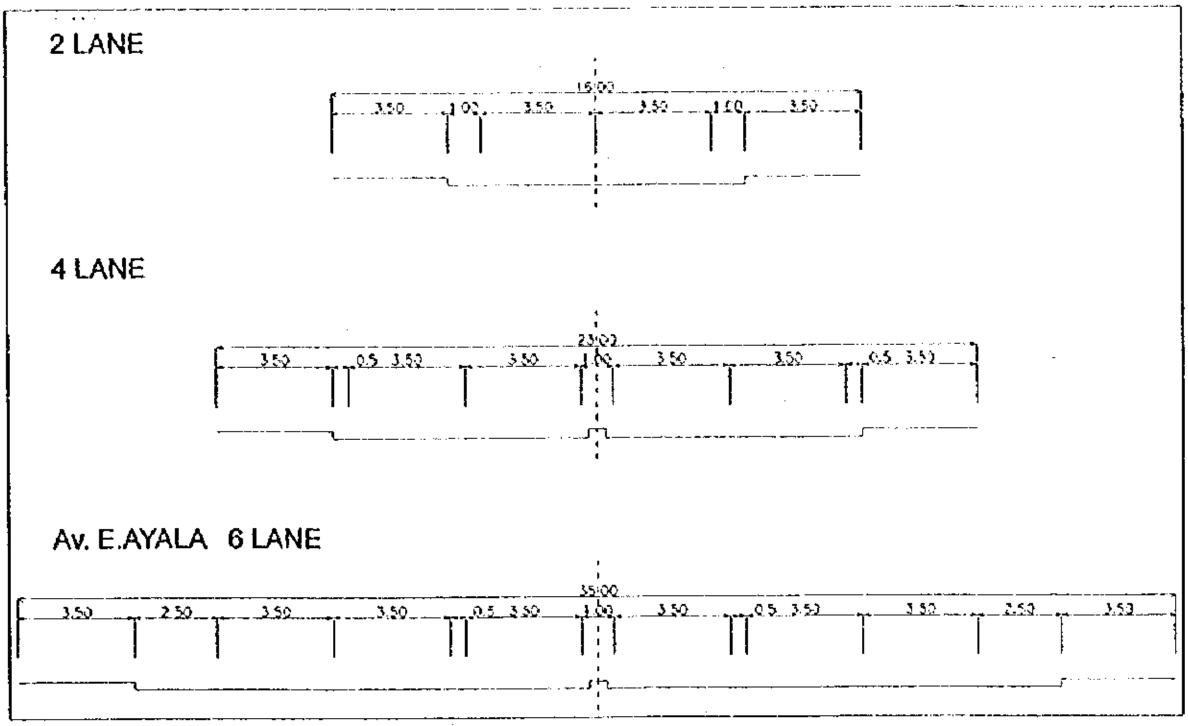

Fig. 13-4-1 Typical Cross Section

Table 13-4-1 Typical Cross Section Elements

Type	Carriageway	Trunk Bus Lane	Sidewalk	Shoulder	Median	Required Land Width
2-lanes	2@3.5m= 7.0m	-	3.5m x 2 =7.0m	1.0m x 2 =2.0m	-	16.0m
4-lanes	2 x 2@3.5m =14.0m	-	3.5m x 2 = 7.0m	0.5m x 2 = 1.0m	1.0m	23.0m
6-lanes (Ave. Ayala)	2 x 2@3.5m =14.0m	2 x 3.5m = 7.0m	3.5m x 2 = 7.0m	2.5m x 2 = 5.0m	-	35.0m

2) Unit Cost of Pavement Works

The same as for earthwork, unit cost of pavement work is determined with reference to "Central Eastern Area Study". The CBR value of 6, which was surveyed on Av. E. Ayala in 1989, was adopted as the typical CBR value used for the determination of pavement thickness in the urban area of Asunción, and pavement works is assumed to be carried out on the sub-base course. In addition, pavement structure is determined as 10cm for the surface course (asphalt pavement), 20cm for the base course, and 70cm for the sub-base course. As a result, unit cost of pavement works is estimated as US$33/m2 in Table 13-4-2. Then unit cost per kilometer is calculated as follows:

2-lanes section: 16m x 1,000m x US$33/m2 = US$528 thousand
4-lanes section: 23m x 1,000m x US$33/m2 = US$759 thousand

Table 13-4-2 Cost Estimation of Pavement

Item			Unit	Description	Assumed Price($/m3)	
					March of 1996	Dec of 1999
Pavement	Flexible Pavement	Asphalt concrete	M3	This is for binder and Surface course	119.6	85.6
		Base	M3	Mechanically stabilized Crushed stone. Combined with transportation costs later	40.4	28.9
		Sub-base	M3	Crusher-run .Finally, combined transport cost	40.4	28.9
	Rigid Pavement	Cement Concrete	M3		135	96.7
		Sub-base	M3	Crusher-run. Finally, combined transport cost	40.4	28.9

Type of surface

Item	(m)	($/m2)
A/C	0.1	8.05
Base	0.2	5.44
Sub-base	0.7	19.04
Total		32.53

Note: /#1 exchange rate between US dollar and Guarani was 2,020Gs./$
/#2 exchange rate between US dollar and Guarani is 3,000Gs./$
source:"The feasibility study on arterial road development project in the central eastern area in the republic of Paraguay" Feb/1997

3) Unit Cost of Land Acquisition

For the estimation of land acquisition cost, unit land prices along the project road were picked up from land prices by block in the urban area of Asunci6n indicated in the "Costos ", and the average of the maximum and the minimum unit value per square meter, which is US$108/m2, is adopted as the unit cost of land acquisition. As a reference, unit land price picked up along each road is shown in Table 13-4-3.

As a result, unit cost of new road construction is estimated as US$2,392 thousand and US$3,439 thousand for 2-lanes and 4-lanes section, respectively.

Table 13-4-3 Unit Land Price

Application of arterial road

Project Number	Name	Location	Min(Gs/m2)	Min($/m2)	Max(Gs/m2)	Max($/m2)	(Min+Max)/2 ($/m2)
104	Anfi Teatro	Tacumbu	60,000	20	200,000	70	45
105/6	Av.Eusebio Ayala	Tembetary	100,000	40	750,000	270	155
107-10	Av.España	San Roque	250,000	90	500,000	180	135
111	Av.Artigas	Jara	100,000	40	150,000	50	45
112	Av.Mcal López	Las Mercedes	180,000	60	600,000	210	135
113	Av.Perú	San Roque	200,000	70	500,000	180	125
114	Av.Gral Santos	Las Mercedes	400,000	140	500,000	180	160
115	Av. Chef. del Chaco	Recoleta	200,000	70	600,000	210	140
116	Av. J. F. Bogado(1ro. de Marzo)	Republicano	100,000	40	600,000	210	125
117	Av. Sta. Teresa	Ycua Sati	300,000	110	400,000	140	125
118	Av.Itá Ybaté	Republicano	40,000	10	80,000	30	20
119	Casique Lambaré	Lambaré	60,000	20	150,000	50	35
120	De la Victoria – Pitantuta	Villa Aurelia	100,000	40	300,000	110	75
124	Av. Bruno Guggiari	Pinoza	100,000	40	600,000	210	125
125	Rca. Agrentina	Recoleta	100,000	40	600,000	210	125
126	Gral. Rafael Franco	Mburicao	100,000	40	200,000	70	55
127	Julio Corréa	Manora	300,000	110	450,000	160	135
129	Conexión Av.Def.del Chaco-Cacique Lambaré	Terminal	400,000	140	600,000	210	175
	Sub Total			62		153	108

Connection of city

Number	Name	Location	Min(Gs/m2)	Min($/m2)	Max(Gs/m2)	Max($/m2)	(Min+Max)/2 ($/m2)
301	Ruta 2	Fdo.de.lamora			80,000	30	30
302	Ruta 1	ditto			80,000	30	30
303	Ruta Ñemby – San Antonio	ditto			80,000	30	30
304	San Antonio – Villa Elisa	ditto			80,000	30	30
305	Villa Elisa – Lambaré	Ita Enramada	60,000	20	150,000	50	35
306	M.R.Alonzo – Luque	Luque			80,000	30	30
307	Acceso al Aeropuerto	Luque			80,000	30	30
	Sub Total			20		33	31

4) Unit Cost of Construction of Fly-over

In order to ease traffic flows along Av. E.Ayala, the construction of fly-overs at five intersections is proposed. Those Locations are intersections with, Av. Kubitscheck, Av. Choferes del Chaco, Av. Republica Argentina, and Av. De la Victoria. Unit construction cost of fly-over is estimated as US$1,250 per square meter, in considering past experience. Each Fly-over is shown in Table 13-4-4.

Table 13-4-4 Cost of Construction for Fly-over

Location of fly-over	Width(m)	Length(m)	Square(m2)	Unit Cost($/m2)	Cost(1000$)
Kubitschek	15.5	560.0	8,680.0	1,250.0	10,850.0
Choferes del Chaco	15.5	400.0	6,200.0	1,250.0	7,750.0
R.Argentina	15.5	520.0	8,060.0	1,250.0	10,075.0
De la Victoria	15.5	515.0	7,982.5	1,250.0	9,978.0
				TOTAL	38,653.0

Note: Unit cost of flyover is estimated 1250$/m2(1999)

5) Unit Cost of Construction of Road along River (Paseo Costanero)

For the estimation of unit construction cost of a road along river (Paseo Costanero), which was planned by the Asunción Municipality, the road was divided into several sections based on the report prepared by the Municipality, and unit construction cost for each section is estimated based on the results of interviews with persons concerned. For the estimation of unit construction cost for this road, land acquisition cost is included.

6) Unit Cost for the Widening of Existing Road

The typical road-widening project in Asunción is widening of Av. E.Ayala from 4-lanes to 6 lanes between intersections with Pettirossi and Av. Mme Lynch with a total length of 6.6km. According to the "Plan de Transporte" prepared by the Asunción Municipality, the total project cost is estimated as US$6,600 thousand and unit cost is calculated as US$1 million at 1994 price (exchange rate of US$1=Gs. 2,020). Therefore, unit cost for the widening of existing road is estimated by considering price conversion between 1994 and 1999 (exchange rate of US$1=Gs. 3,000), as follows:

US$1 in million x 0.67 = US$670 in thousand.

This unit cost is adopted for widening of existing road both from 4-lanes to 6-lanes and 2-lanes to 4-lanes. In addition, as for the construction of a new road, land acquisition cost is estimated based on the data of unit land price presented in "Costos", if land acquisition is required by widening of the existing road. Then unit cost per kilometer is calculated as follows:

4-lanes widening: US$670,000+(23m-16m) x 1,000m x US$108/m2 = US$1426 in thousand
6-lanes widening: US$670,000+(36m-23m) x 1,000m x US$108/m2 = US$1966 in thousand

(2) Unit Cost for the Improvement of Intersection

Unit cost for the improvement of intersection is estimated based on the result of the Feasibility Study in 1988 for the improvement of Tacuary Intersection located in Centro. The direct financial cost for this improvement was estimated as Gs.136 in million and the total project cost including indirect cost was estimated as:

Gs. 136 in million x 1.59 (ratio of indirect cost) = Gs. 216 in million
Gs. 216 in million / Gs.850/US$1 = US$250 in thousand.

In order to estimate the unit cost in 1999 prices, the devaluation of Gs. (US$1=Gs.850 in 1988 and US$1=Gs.3,000 in 1999) was considered and the unit cost is estimated as:

US$250 in thousand x Gs.850/Gs.3, 000 = US$71 in thousand per one.

(3) Unit Cost for the Improvement of Drainage Facilities

1) Unit Cost for the Construction of Transverse Drainage Pipe

Unit cost for the construction of transverse drainage is estimated with a reference to unit cost used in the "Central Eastern Area Study". It is estimated US$279 per meter.

2) Unit Cost for the Improvement of Drainage Facilities at Intersection

Unit cost for the improvement of drainage facilities at intersection is estimated with reference to unit cost of bidding for the improvement of Av. Mme Lynch estimated by MOPC. As a standard of improvement, construction of one 2.0m x 2.0m catch-basin, one 0.8m x 1.0m catch-basin, two 0.57m x 0.75m catch basin, ϕ 0.5m of transverse pipe culvert for 20m, and ϕ 0.3m of transverse pipe culvert for 10m are considered to be included.

As a result, unit cost for the improvement of drainage facilities at intersection is estimated as follows:

Construction of catch-basin Gs.1, 563,200 x 4 = Gs. 6,252,800
Unit construction cost of transverse pipe culvert per one meter diameter for one meter
In length: Gs. 555,547
Hence, unit construction cost of transverse pipe culvert is estimated as:
(0.5m x 20m + 0.3m x 10m) x Gs.555, 547 = Gs. 7,222,111
Total unit cost is Gs.6252, 800 + Gs. 7,222,111 = Gs. 13,474,111
= US$ 4.5 in thousand

Table 13-4-5 Cost Estimation of Drainage at Intersection

No	Item	Unit	Min	Max	Average	Cost($/1)
1	Asphalt Concrete Pavement	Gs/m3	190,500	338,039	264,270	88
2	Base Concrete	Gs/m3	232,570	253,539	243,055	81
3	Sub-base (Crush-run)	Gs/m3	84,100			28
4	L gutter	Gs/ml	30,420	36,420	33,420	11
5	Concrete pipe D=1	Gs/ml	485,613	625,480	555,547	185
6	Catch-basin(Type A)	Gs/un	1,563,200			521
7	Transverse Catch-basin	Gs/un	3,252,800			1,084
8	Manhole Class 1	Gs/un	2,916,000			972
9	Manhole Class 2	Gs/un	3,118,000			1,039

Source: MOPC (Tender Price of Av. Madame Lynch)
/1:1$=3000Gs(1999)

(4) Recapitulation

Based on the above, unit cost for each work item is summarized in Table 13-4-6.

Table 13-4-6 Summary of Unit Cost

No.	Item	Sub-Item	Unit	Cost(1000$)/1	Note
1	Road construction and pavement	1)New Road Construction	km	2,392	2lane
			km	3,439	4lane
		2)Pavement	m2	0.033	
		3)Fly-over	m2	1.25	
2	Road widening		km	1,426	2lane-4lane
				1,966	4lane-6lane
3	Intersection improvement		Number	71	Per 1intersection
4	Drainage Improvement	1)Drainage (latitude)	km	279	
		2)Intersection	Number	5	Per 1intersection

/1:1$=3000Gs(1999)

13.4.2 Unit Cost for Introduction of Alternative Transport Modes

Other than bus transportation, unit cost for introduction of trolley bus system and light rail transit (LRT), which are considered to be alternative transport modes in this study, are also estimated.

(1) Unit Cost for Introduction of Trolley Bus System

Based on the feasibility study on introduction of trolley bus system on Av. E.Ayala conducted by MOPC in 1997 (Plan Maestro de las Vias de Accesso a la Ciudad de Asunción, Informe Final tomo3), total project cost and total length are accumulated, and unit cost for introduction of trolley bus is estimated as shown in Table 13-4-7.

Table 13-4-7 Unit Cost for Introduction of Trolley Bus System

Item	Unit cost (US$)	Surface(m2) or Unit	Total Cost (US$)	
			1996 2160Gs./US	1999 3000Gs./US
Land	20	12,000	240,000	172,800
Parking and flow	28	3,360	94,000	67,680
Main Building	360	700	252,000	181,440
workshop and warehouse	180	1,040	187,000	134,640
Pedestrian area	11	2,000	22,000	15,840
Light pole	250	16	4,000	2,880
Sub-station1	600,000	1	600,000	432,000
Sub-station2	1,160,000	1	1,160,000	835,200
Single Net	80,000	9	720,000	518,400
Double Net	120,000	7	780,000	561,600
Accessory Net	Global	-----	141,000	101,520
Engineering Service	Global	-----	400,000	288,000
Total(i)	-----	-----	4,600,000	3,312,000
Cost of Total Operation per year				
Cost of Total Operation(ii)	-----	-----	3,783,000	2,723,760
Total(i+ii)	6,454,910			6,035,760

Pre-feasiblity technical final result of trolley buses – Ayala line

Total length(km)	21
Total network length(km)	22
Travel time(min)	50
Total travel time(min)	55
Demand of passenger (per)	4,040
Frequency of rush hour (veh/h)	40
Total Fleet (vehicles)	42
Total unit cost per km:(US$)	**293,405**

(2) Unit Cost for Introduction of Light Rail Transit (LRT)

In this study, introduction of Light Rail Transit system is considered as an alternative for introduction of trunk bus service along Av. E. Ayala, because construction cost of LRT system is cheaper than other mass transit systems. Based on information obtained from Columbia and Peru, therefore, unit cost for introduction of LRT system is estimated as US$25 in million per kilometer.

Chapter 14 Traffic Management Plan

14.1 Present Issues on Traffic Management

The following are the present issues on traffic management;

- The organizations in charge of planning and enforcement of traffic management are neither unified nor well coordinated.
- There are few signals for pedestrians and, even though there are some, they are not well recognized by pedestrians because of the bad installation locations.
- All red and yellow times in a signal cycle are short, which causes many traffic accidents.
- Most of the signal phases are fixed, and they do not reflect the traffic flow changes.
- The signal cycles are long, which decreases the service level.
- At signalized intersections, spaces for left-turning traffic are not sufficient, which obstructs straight traffic.
- Road signs are not very recognizable due to vegetation, and pavement markings are not well maintained. Especially in Micro Centro, where almost all the streets are one-way, the signs and pavement markings are important.

14.2 Basic Policy for Traffic Management Plan

(1) Coordination among Organizations

It is desirable that the organizations responsible for policy making, planning, implementation and enforcement of traffic management are unified, but it is practical to establish a coordination system among the organizations. In addition to these functions, this coordination system should include the organizations responsible for road construction and public transport administration, and mutual projects should be well coordinated.

(2) Establishment of Management Standard

Countermeasures such as installation of signals and improvement of intersections should be implemented to mitigate traffic congestion and for traffic safety day by day. In these cases, they should not be carried out based not only on past experience, but also on installation standards developed from the viewpoint of engineering technology and the past data collected.

(3) Establishment of Sustainable Management System

Traffic changes constantly, and thus it is necessary to monitor the flows, even if the traffic management facilities are installed and operated based on the management standard, to cope with these changes. For this purpose, it is necessary to establish an exclusive section for the periodic monitoring of traffic flow and information, and to prepare a budget.

14.3 Traffic Management Projects

Projects recommended for the improvement of the safety and smooth processing of traffic are the following.

1) Construction of bus bays

Bus bays are constructed on trunk roads to reduce the influence of bus operation and ensure the smooth flow of other traffic.

2) Installation of signals

Signals are newly installed on intersections with a large traffic volume to improve traffic safety and smooth traffic processing. In addition, in order to control traffic properly, more vehicle detectors are added to major intersections, and traffic information is collected and processed.

3) Improvement of signs and road markings

4) Installation of central reserve

Central reserves are installed on minor intersections of trunk roads in order to keep vehicles from crossing from minor streets.

5) Widening of sidewalks

In Micro Centro, which has many pedestrians, some sidewalks are widened.

6) Establishment of Traffic Volume Monitoring System

It is suggested that a system and organization that regularly monitors traffic volume be created just like population statistics. This will make it possible to formulate road traffic control plans, based on traffic conditions and data.

Table 14-3-1 List of Traffic Management Projects

	Number	Name	Lanes	Length (km)
Public Transportation				
		Bus Bays		
	601	Av. Fdo. de la Mora	4	5.86
	602	Av. Artigas	4	4.09
	603	Av.Mcal. López	4	7.97
	604	Av.Jose Felix Bogado	4	3.65
Traffic Control				
	702	Signal System		229
	711	Road Sign		
		Av. Fdo. de la Mora	4	5.86
		Installation of central reserve		
	703	Av.Jose Felix Bogado	4	3.65
	704	Av.Fdo de la Mora	4	5.86
	705	Av.Mcal. López	4	7.97
	706	Av.Artigas	4	4.09
	707	Av.Gral. Santos	4	3.80
	708	Av.Kubitscheck-Brasilia	4	5.47
	709	Av.Chef.Chaco-Sacramento	4	6.18
	710	Av.San Martin	4	6.41
	701	Widening of sidewalks		
		Sta.Rosa		0.35

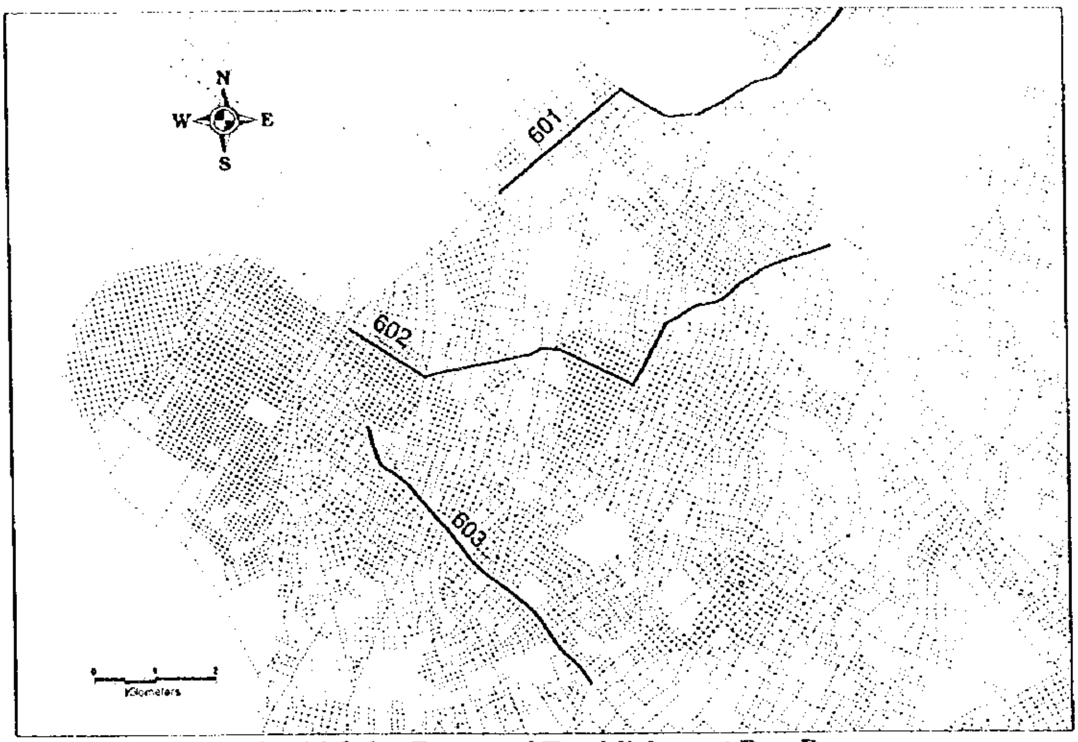

Fig. 14-3-1 Routes of Establishment Bus-Bay

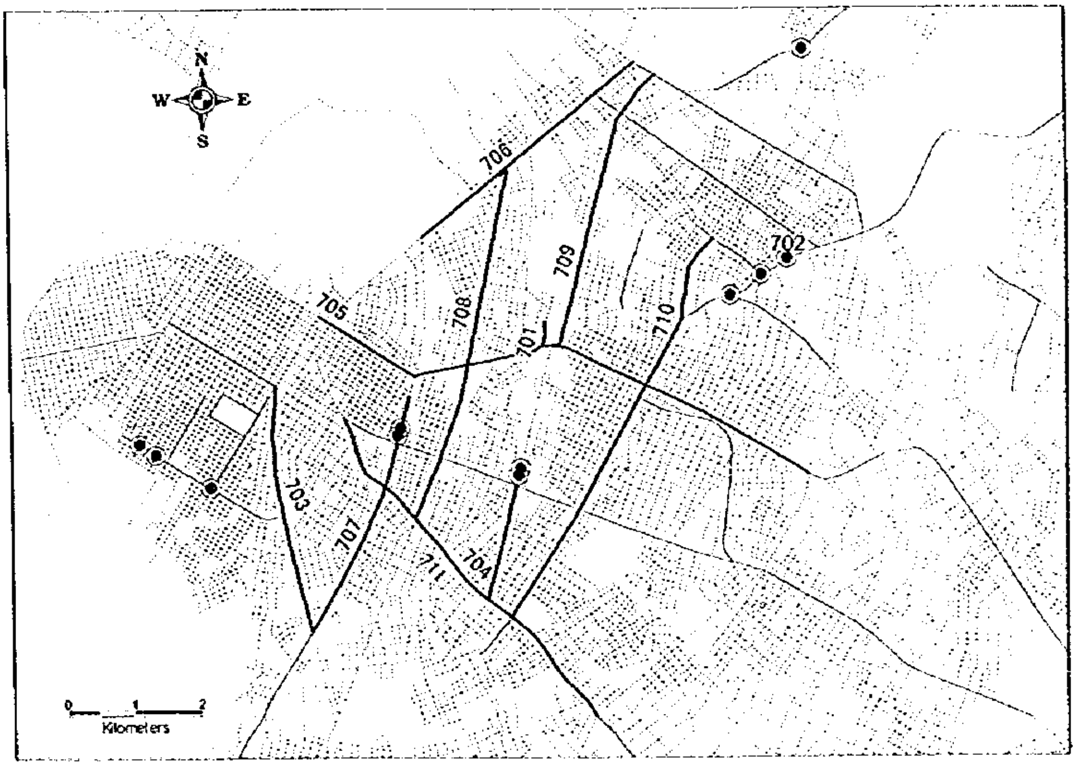

Fig. 14-3-2 Projects of Traffic Control

14.4 Traffic Management Policy in Micro-Centro

Existing conditions and future traffic problems in Micro-Centro are described below.

- This area is the center of business and commerce, attracts many trips for work and shopping. Volume of generation and attraction is expected to increase by 1.6 times, which makes traffic congestion even more severe.

- Present capacity of on- and off-street parking is approximately 10,000. Currently, almost 100 percent of on-street and about 67 percent of off-street parking facilities are being used, and the remaining capacity is less than 2,000. With an increase in generation and attraction by 1.5 times, parking demand similarly increases by 120,000 vehicles, and there will be a lack of parking spaces.

- According to the environmental survey, this area contains a high density of NOx. If the traffic concentration continues, the environment is expected to worsen.

It is likely, therefore, that Micro-Centro needs to restrict vehicles entering. This section makes two suggestions. They are based on users' requests obtained from the interview survey by the study team in Micro Centro (See Fig. 14-4-1).

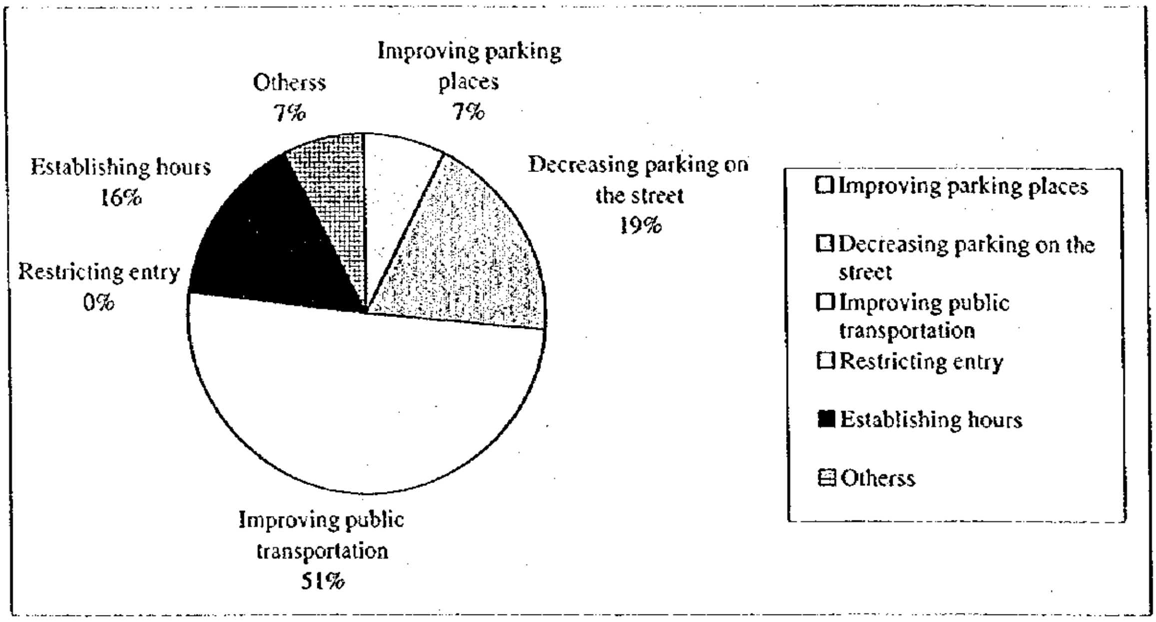

Fig. 14-4-1 How to Improve

(1) Restrictions on Inflow Traffic

In 2015, the number of passenger vehicle trips attracted to Micro Centro is, as shown in Table 14-4-1, 150,000 in total and 81,000 for work. They constitute 6.9% and 3.7%, respectively, of the total passenger vehicle trip in the city.

During the morning and evening rush hours, a large volume of work trips is attracted and creates congestion that is further worsened by on-street parking. It is predicted that traffic congestion will worsen in 2015.

The Master Plan gives priority to public transportation and attempts to improve its service level. It proposes restrictions on vehicles entering an area of 0.32km^2 as shown in Fig. 14-4-2, in order to help promote modal conversion from private to public transport, enhance smooth flow of traffic, and keep sufficient pedestrian spaces in Centro. In response to the traffic volume, the restriction will be imposed for a period of two hours from 7 to 9 in the morning.

Table 14-4-1 Passenger Vehicle Work Trips to Micro Cenro

Descriptions	1998	2005	2015
Trips/day			
Total Trip	2,289,174	3,145,483	4,062,092
Vehicle Trip	1,138,960	1,683,781	2,182,261
Vehicle Trip to Centro	98,777	123,686	150,284
Vehicle Work Trip to Centro	59,733	66,004	80,714
Share to Total Trips (%)			
Vehicle Trip	49.8	53.5	53.7
Vehicle Trip to Centro	4.3	3.9	3.7
Vehicle Work Trip to Centro	2.6	2.1	2.0

Micro-Centro; Zona 4(Catedral),9(Encarnación)

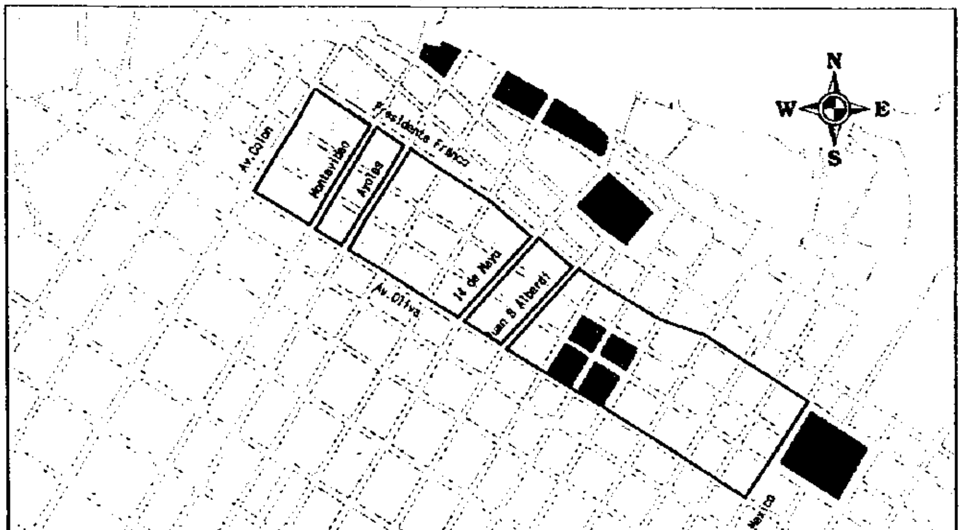

Fig. 14-4-2 Restrictions on Inflow Traffic into Micro Centro

According to the interview survey of 100 drivers in Micro Centro by the Study team, as shown in Fig. 14-4-3, 19 percent of the respondents said that they would convert their mode of travel to public transportation if this type of restriction were to be introduced.

There are 81,000 work trips in the study area, and with an occupancy rate of 1.61 persons/vehicle, the number of vehicles is calculated as 50,300. Supposing 80 percent of them are attracted during the peak period, the number would be 40,240 vehicles. Among them, therefore, about 7,650 vehicles would be converted to bus.

Moreover, an introduction of the restriction would require walking from outside the area. According to the survey, 48 percent responded that they would walk up to 5 blocks, and thus the restriction would have little impact on pedestrians.

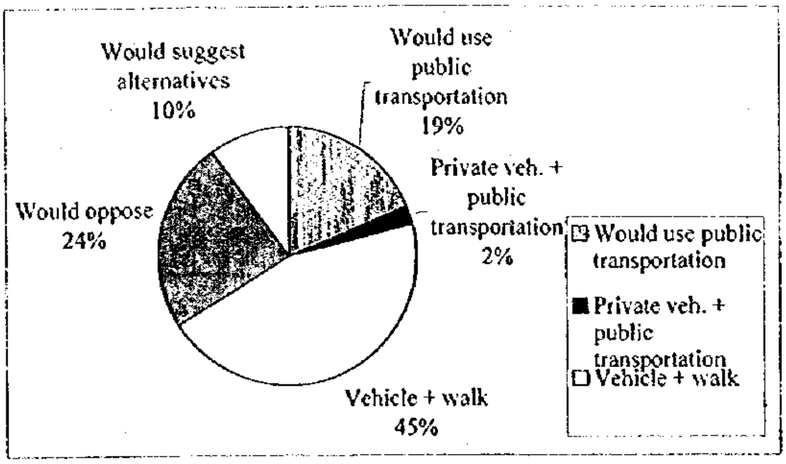

Fig. 14-4-3 Opinions on Conversion to Bus Use by Passenger Vehicle Users

(2) Parking Restrictions

Another measure of control on car use is parking restriction. The results of the survey show that 19 percent of car users said that the reduction of on-street parking could be a solution to congestion.

In the area where the restrictions on inflow traffic are to be imposed, the current capacity of parking, both on- and off-street, is about 2,300 vehicles, and there is predicted to be a lack of parking spaces in 2015.

According to the survey, as shown in Fig. 14-4-4, 50 percent of the respondents say that they would use the bus if the parking toll is raised from the current level of Gs1,350 per hour to Gs3,000. This indicates that an increase in parking toll can be an effective measure for reducing the demand for private car use. If this measure were to be taken in the study area, about 56,000 trips would be converted into bus use by 2015, or about 17,000 vehicles would be put away from the area.

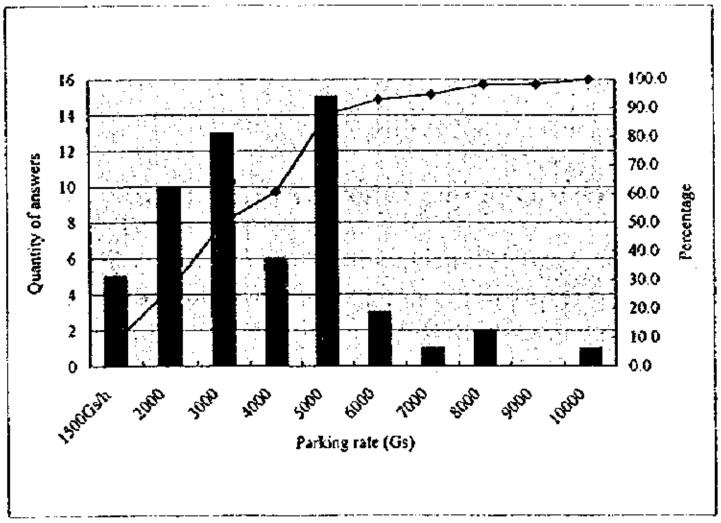

Fig. 14-4-4 Conversion into Bus Use as a Result of On-Street Parking Tariff Increase

14.5 Cost Estimate

14.5.1 Determination of Unit Cost for Cost Estimation

Unit costs used for the cost estimation of the following projects, which are included in the Master Plan with a target year of 2015 and higher priority projects for the Feasibility Study with a target year of 2005, have been determined;

- Construction of bus-bays
- Installation of traffic signals
- Facilities related to traffic operation(widening of sidewalks, installation of pavement marking and traffic signs, and closure of median openings)

(1) Construction of Bus-bay

1) Construction of New Bus-bay

Construction of bus-bays for 500m interval along major trunk road is proposed and unit cost of construction of one bus-bay is estimated. For each bus-bay, specification is considered as follows:

Width of bus-bay: 2.5m
Deceleration lane length: 20m
Acceleration lane length: 25m
Number of stopping buses: 3 buses at the same time
Occupancy of a bus: 15m

As a result, necessary pavement area is calculated as 282m2
Then, the unit construction cost is estimated by using unit cost of pavement work (US$33/m2) as:

282m2 x US$33/m2 = US$9 in thousand

2) Construction of New Bus-bay along Trunk Bus Route

At bus stops for the service of trunk buses (express buses), construction of a pedestrian overpass is also considered together with construction of bus-bays. The interval of construction of this type of bus-bay is planned as 1.5km. Therefore, these types of bus-bays (both sides) are necessary at 8 locations and 6 locations for the whole stretch of Av. E.Ayara (10.99km) and Av. Mcal López (8.4km), respectively. For the unit cost, unit construction cost of a pedestrian overpass, US$40 in thousand (obtained from AGA) is added to the unit construction cost of an ordinary bus-bay mentioned above. Then the unit cost is estimated US$58 in thousand.

(2) Unit Cost for the Installation of Traffic Signal

Unit cost for the installation of traffic signals is estimated based on the result of the Feasibility Study in 1988 for the installation of traffic signals in Centro. The direct financial cost for installation of traffic signal was estimated as Gs.1,080 in million and the total project cost including indirect cost was estimated as:

Gs. 1,080 in million x 1.59 (ratio of indirect cost) = Gs. 1,717 in million
Gs. 1,717 in million / Gs.850/US$1 = US$2.02 in million.

In order to estimate the unit cost in 1999 prices, the devaluation of Gs. (US$1=Gs.850 in 1988 and US$1=Gs.3,000 in 1999) was considered and the unit cost is estimated as:

US$2.02 in million x Gs.850/Gs.3,000 = US$572 in thousand

Since the total number of traffic signal installations in the Feasibility Study was 51 locations, unit cost of installation of traffic signal at one intersection is estimated as US$11,216. Since replacement of only unsynchronized traffic signals are proposed in this study, the total number of intersection for installation of new traffic signal is considered to be 118 locations.

(3) Unit Cost of Installation of Facilities related to Traffic Operation (widening of sidewalks, installation of pavement marking and traffic signs, and closure of median openings)

1) Unit Cost for Installation of Traffic Signs and Pavement Marking

According to the "Feasibility Study Report in 1988", installation of pavement marking (markings of zebra crossings, stopping lines, deceleration lane, etc.) and traffic signs in the Centro were recommended. Therefore, unit cost for installation of traffic signs and pavement markings are estimated based on the installation cost mentioned in the "Feasibility Study Report in 1988".

The direct financial cost for this improvement was estimated as Gs.73 in million and the total project cost including indirect cost was estimated as:

Gs. 73 in million x 1.59 (ratio of indirect cost) = Gs. 116 in million
Gs. 116 in million / Gs.850/US$1 = US$140 in thousand.

In order to estimate the unit cost in 1999 price, the devaluation of Gs. (US$1=Gs.850 in 1988 and US$1=Gs.3,000 in 1999) was considered and the total cost is estimated as:

US$140 in thousand x Gs.850/Gs.3,000 = US$40 in thousand

As the number of locations for installation of these facilities recommended in the Feasibility Study was 25, unit cost for installation of these facilities is calculated as US$1600 per location.

In this study, installation of traffic signs and pavement marking at 59 locations is proposed, under the assumption that interval of intersections along Ave. Fernando de la Mora is 100m for the whole stretch of 5.86km. As a result, the total cost for installation is estimated as:

US$1600 x 59 = US$94.4 in thousand

2) Unit Cost for Closure of Median Openings

In order to secure smooth traffic flows and to prevent traffic accidents, closure of most of the median openings, other than only one opening per kilometer, is proposed. In the regard, 9 out of 10 median openings are proposed to be closed, under the assumption that length of one block is 100m. In considering the carriageway width, length of a median opening is assumed to be 10m, and the total length of median openings per kilometer proposed to be closed is estimated as 90m.

In this study, unit cost for construction of sidewalk is adopted as unit cost for closure of median opening. In the "Feasibility Study Report in 1988", total cost for construction of side walks of 2.0m width for 1,650m of section (Av. 15 de Agosto 550m, Ave. Chile 550m, and Ave. Yegros) was estimated as Gs. 556 in million. Therefore, unit cost for construction of sidewalk per meter is calculated as Gs. 337 in thousand. As it is necessary to close 90m of median openings per km, unit cost for closure of median opening per kilometer is calculated as:

Gs. 30.33 in million = US$36 in thousand (in 1988 price)

In order to estimate the unit cost in 1999 price, the devaluation of Gs. (US$1=Gs.850 in 1988 and US$1=Gs.3,000 in 1999) was considered and the unit cost in 1999 price is estimated as:

US$36 in thousand x Gs.850/Gs.3,000 = US$10.2 in thousand

3) Unit Cost for Widening of Sidewalk

Based on the unit cost for closure of median opening, unit cost for widening of sidewalk on both sides is calculated as US$20.4 in thousand per kilometer.

(4) Recapitulation

Based on the above, unit cost for traffic management project items are summarized in Table 14-5-1.

Table 14-5-1 Summary of Unit Cost

No.	Item	Sub-Item	Unit	Cost(1000$)/1	Note
1	Bus-Bay	Bus-Bay(normal)	Number	9	New Construction
		Bus-Bay(Trunk bus route)	Number	58	
2	Signal		Number	11	Per 1intersection
3	Traffic Management	1)Sidewalk	km	21	
		2)Road marking/Sign	Number	1.6	
		3)Closing Center Reserve	km	10	

/1:1$=3,000Gs(1999)