9.4 Trip Generation and Attraction

Estimated trip generation and attraction in the year 2020 according to the integrated zone are shown in Table 9.4-1. Figure 9.4-1 shows a comparison between the figures in 1995 and 2020 in which "to home" trips are excluded to clearly show the characteristics of generation and attraction. As seen, the increase rates of trip generation between 1995 and 2020 in northern and western areas are dramatically higher (2.0-5.0), while in central area they are somewhat higher (1.2-1.8).

As for trip attraction, the increase rate of the central area is higher (1.3-1.9), in contrast to 1.2-1.8 of the generation. In the northern area, the figures are also higher (1.5-4.5). This is because work-place/school-place base population (employment) is substantially concentrated in the central area when the distribution of population is compared.

Figure 9.4-2 and Figure 9.4-3 show the public mode trip generation and attraction by purpose in 1995 and 2020 in which "to home" trips are excluded to cleary show the characteristics of generation and attraction. Figure 9.4-4 and Figure 9.4-5 also show the generation and attraction of the private mode. Both figures indicate the volume by size of circle.

As seen in the trip generation and attraction of the public mode in 1995 and 2020, estimated volumes by zone in 2020 show similar patterns as that of present. This is due to the fact that the number of the non-motorized households, which strongly relate to public mode trips, are estimated in the similar distribution as that of present.

On the other hand, the characteristics of trip generation and attraction by private mode in 1995 and 2020 differ from zone to zone. The trip generation is large except in the western fringe of boundary of Bogota and southern area. The areas with large volume in car trip attraction in 2020 concentrate in existing business/commercial areas and the northern area.

Table 9.4-1 (1) Trip Generation and Attraction in 2020

	Generation									
	To Work		To School		Business		Private		To Home	
zone	car	bus	car	bus	car	bus	car	bus	car	bus
1	29,261	43,128	7,364	40,242	9,408	8,729	35,853	17,251	102,651	218,994
2	77,283	66,207	19,420	82,277	26,686	8,550	73,515	31,810	109,129	104,807
3	71,447	32,458	16,138	48,776	30,336	7,156	75,916	21,787	168,819	159,285
4	66,080	11,317	15,912	40,771	52,153	7,492	83,732	17,409	236,402	187,619
5	24,834	24,352	10,751	39,297	31,331	12,017	68,224	24,840	186,513	393,696
6	18,337	55,348	10,806	42,413	53,777	28,442	60,044	46,823	219,212	831,662
7	42,128	183,588	8,468	80,475	24,072	13,894	27,255	54,872	42,849	90,467
8	15,671	93,846	2,658	39,392	9,359	5,451	6,642	27,875	9,361	42,469
9	29,396	105,621	4,349	50,895	22,550	8,759	24,585	39,689	39,809	93,980
10	33,493	108,134	3,876	54,259	8,108	7,969	20,497	36,553	45,180	75,432
11	94,619	242,506	12,941	144,256	66,779	19,108	61,631	81,191	120,707	197,490
12	46,327	37,532	13,058	49,617	8,471	3,325	36,927	14,437	47,061	33,773
13	30,298	24,188	8,236	41,960	12,141	5,126	26,201	12,489	39,157	65,442
14	41,492	93,375	6,762	59,449	20,263	10,112	33,155	36,124	80,231	138,997
15	107,119	226,004	23,378	163,538	41,171	21,330	97,262	88,151	142,746	221,144
16	50,203	141,508	12,600	84,710	13,714	10,112	34,438	51,636	45,652	60,644
17	87,662	51,094	18,022	71,229	23,741	9,953	75,696	22,185	96,591	82,656
18	124,271	84,007	36,651	117,131	16,120	6,024	103,961	45,614	180,145	135,326
19	58,603	131,557	11,205	83,089	18,209	12,335	39,976	52,519	53,104	89,209
20	55,834	87,464	14,578	68,269	28,680	10,134	70,081	35,847	137,588	200,017
21	68,148	61,040	18,784	84,044	45,999	14,691	102,085	45,756	239,689	360,818
22	30,964	40,718	6,417	41,663	31,253	13,794	53,902	27,669	124,590	234,911
23	50,865	53,542	10,659	44,221	14,722	7,171	30,429	19,762	53,352	101,108
24	83,989	154,296	31,421	108,185	43,873	34,206	88,131	67,114	135,578	313,123
25	2,557	11,186	1,770	6,115	4,027	2,031	6,951	6,758	21,632	106,566
26	47,056	142,904	7,535	70,255	26,164	12,457	36,951	49,681	58,686	144,657
27	33,426	172,356	12,730	69,995	20,326	12,961	25,873	57,233	54,679	91,398
28	0	0	0	0	0	0	0	0	0	0
29	467	219	261	995	6,781	1,058	5,410	1,025	26,984	56,471
30	6	128	8	129	3,378	168	767	133	1,285	2,610
31	0	0	373	213	755	249	1,075	409	12,779	9,468
32	17	505	57	1,002	10,898	580	10,911	832	22,520	26,638
33	258	935	285	332	17,395	1,773	11,394	1,220	13,121	41,663
34	7	210	189	311	3,795	182	111	261	2,283	7,179
35	186	526	14	302	0	0	987	348	2,302	1,558
36	10	288	0	0	0	0	0	0	801	313
37	139	394	146	0	0	0	724	0	4,334	1,303
38	0	0	0	0	669	157	188	447	412	3,224
Total	1,422,453	2,482,480	348,042	1,829,807	747,004	317,496	1,421,480	1,037,750	2,877,931	4,926,117

Table 9.4-1 (2) Trip Generation and Attraction in 2020

	Attraction									
	To Work		To School		Business		Private		To Home	
zone	car	bus	car	bus	car	bus	car	bus	car	bus
1	53,641	51,741	12,595	164,490	15,622	8,104	46,317	23,473	65,261	93,214
2	44,945	49,433	17,924	44,359	19,613	7,967	55,430	21,543	152,589	164,547
3	76,447	112,353	15,150	39,999	35,951	12,400	90,793	30,237	146,929	93,372
4	114,743	145,325	42,144	42,326	55,354	13,273	96,325	27,311	148,737	64,339
5	65,633	171,446	44,057	204,086	39,862	19,323	98,040	68,576	84,617	81,678
6	93,577	468,770	46,098	253,134	94,361	54,452	144,361	173,605	80,901	135,962
7	24,441	32,458	2,236	34,928	14,548	8,951	15,637	28,997	71,550	296,784
8	6,513	14,982	22	15,235	5,395	3,102	1,971	15,421	24,074	148,656
9	20,096	34,943	2,606	44,316	12,376	7,079	20,010	26,607	51,896	179,475
10	28,175	29,399	1,544	23,803	7,376	9,493	19,316	24,869	52,656	181,712
11	84,991	91,675	3,141	63,401	43,968	15,658	43,547	57,219	156,178	435,378
12	28,279	19,700	1,195	8,933	6,971	3,871	19,685	8,932	86,468	92,774
13	24,701	44,781	2,374	8,071	10,812	5,260	22,338	14,769	57,988	71,739
14	54,999	94,673	2,717	30,094	23,355	9,371	36,717	25,134	73,276	171,488
15	65,068	93,126	20,687	95,559	29,984	18,194	68,949	53,240	204,266	440,866
16	28,899	24,760	1,767	21,310	8,301	6,312	16,591	20,621	88,426	253,672
17	39,482	47,688	8,772	21,463	15,419	7,382	54,709	22,577	162,825	130,140
18	88,722	20,206	35,248	109,375	20,574	5,599	68,345	13,216	238,518	229,202
19	36,384	28,650	2,299	32,716	11,750	9,078	18,368	32,685	98,450	246,835
20	66,045	115,171	7,829	67,322	28,984	12,354	78,231	40,284	126,158	173,657
21	107,134	176,812	31,105	144,547	51,521	15,735	124,094	73,648	169,491	175,695
22	68,084	146,269	6,638	64,254	33,247	11,509	65,297	50,479	82,016	100,274
23	25,464	43,963	4,050	45,090	14,618	7,457	24,222	23,994	82,632	108,429
24	81,197	227,035	7,713	54,652	36,507	18,676	60,856	63,196	181,103	308,822
25	9,995	41,117	7,892	66,623	5,443	3,960	14,003	12,013	10,465	22,677
26	25,951	43,821	10,836	76,601	14,940	9,264	28,682	35,863	84,960	240,528
27	39,482	42,397	252	20,506	15,053	7,940	13,921	34,431	64,396	272,476
28	0	0	0	0	0	0	0	0	0	70
29	3,903	13,085	2,026	17,373	19,870	1,232	24,651	2,805	5,493	2,180
30	818	2,630	0	90	2,445	178	293	60	690	428
31	1,082	3,345	6,335	6,081	2,600	404	5,556	76	1,337	613
32	6,432	13,447	376	7,230	18,526	1,499	22,195	3,296	10,434	2,398
33	4,165	29,814	414	932	19,110	1,744	13,135	5,521	10,707	2,750
34	1,045	3,871	0	818	4,328	50	1,601	542	285	800
35	210	1,693	0	0	1,245	32	2,251	284	1,059	1,086
36	877	439	0	0	1,675	0	594	530	12	396
37	602	1,325	0	0	4,711	225	2,922	276	914	461
38	231	237	0	90	589	368	1,527	1,420	177	544
Total	1,422,453	2,482,480	348,042	1,829,807	747,004	317,496	1,421,480	1,037,750	2,877,934	4,926,117

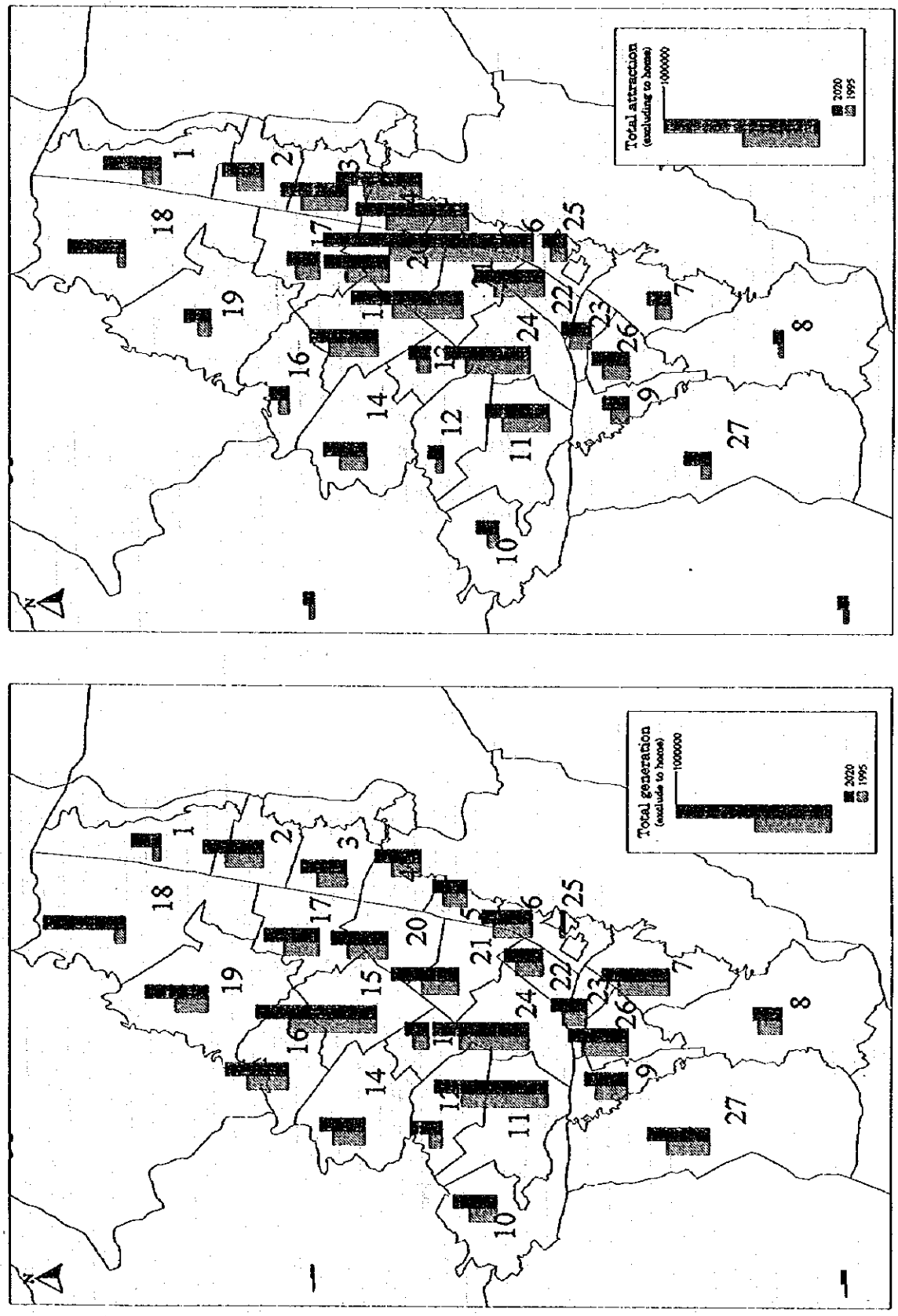


Figure 9.4-1 Trip Generation and Attraction in 1995 and 2020

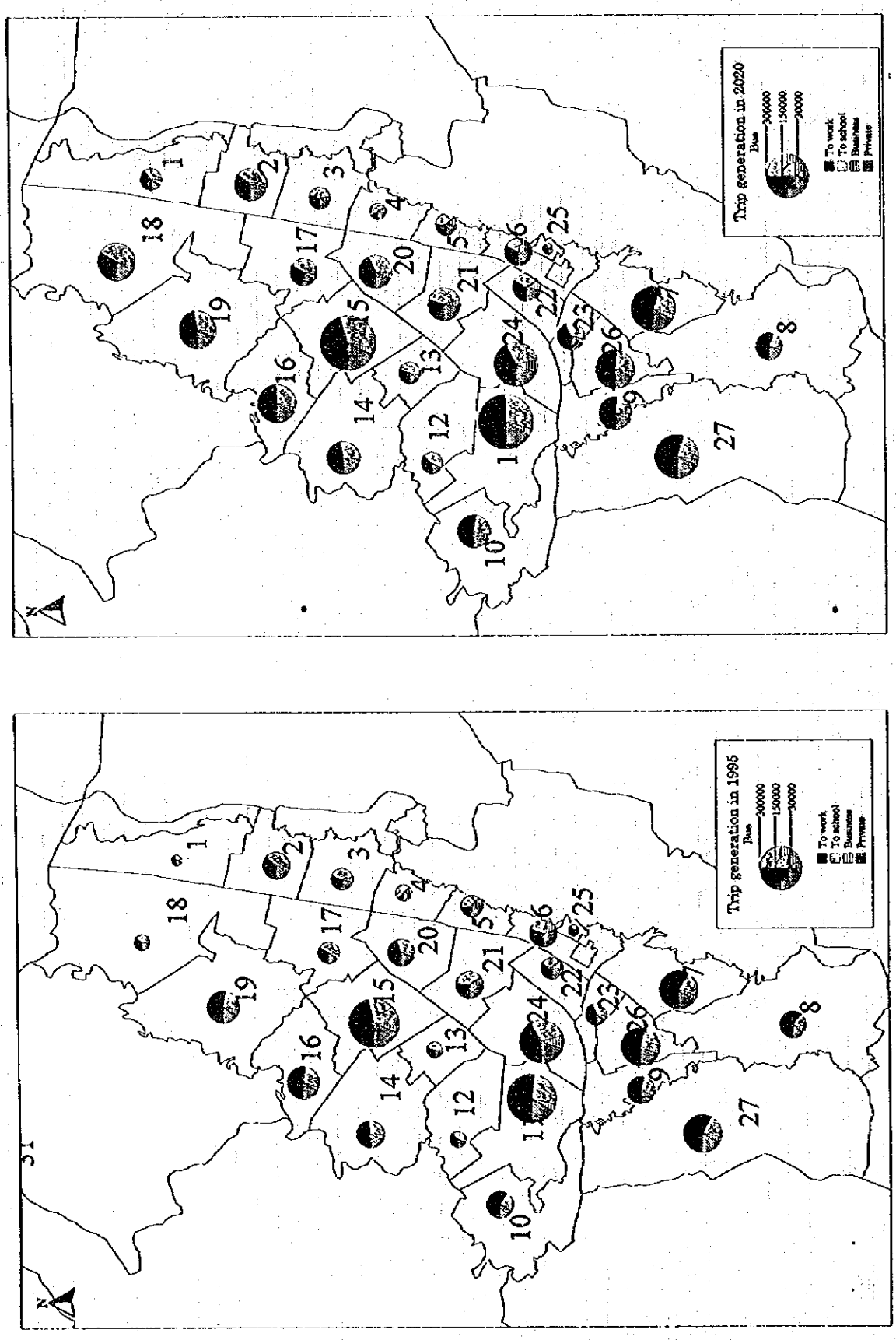
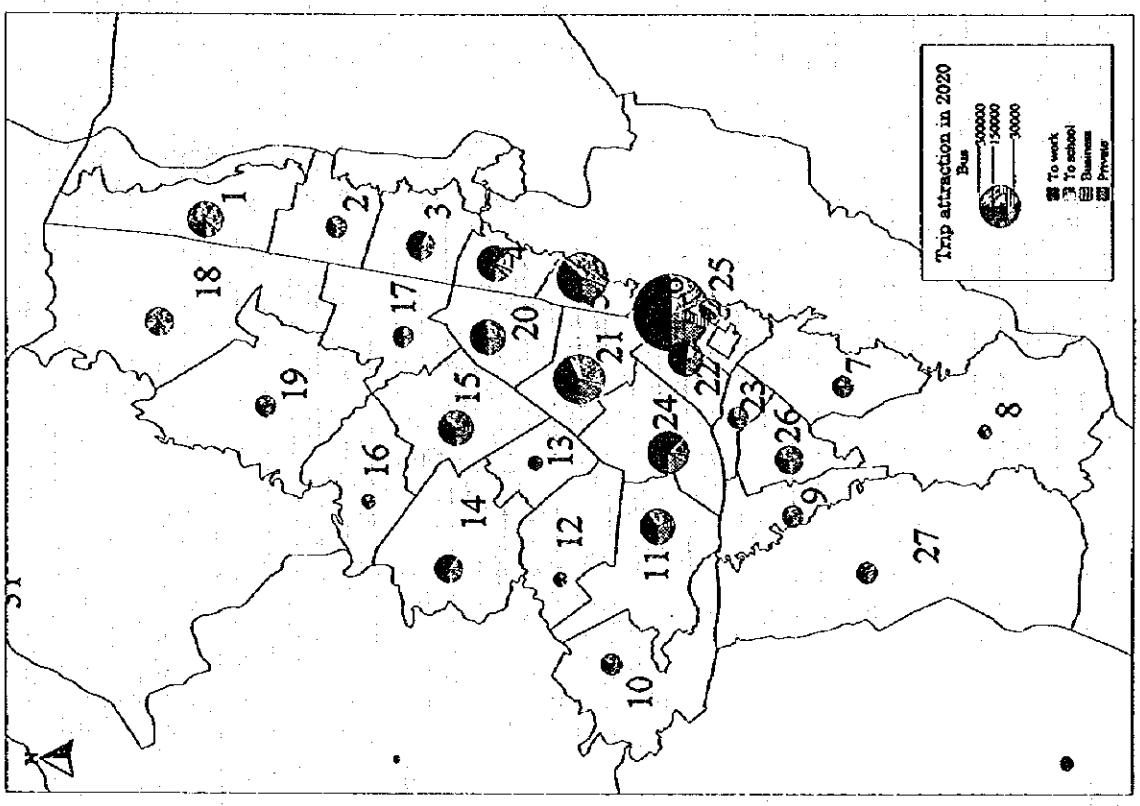


Figure 9.4-2Trip Generation by Public Mode (1995/2020)



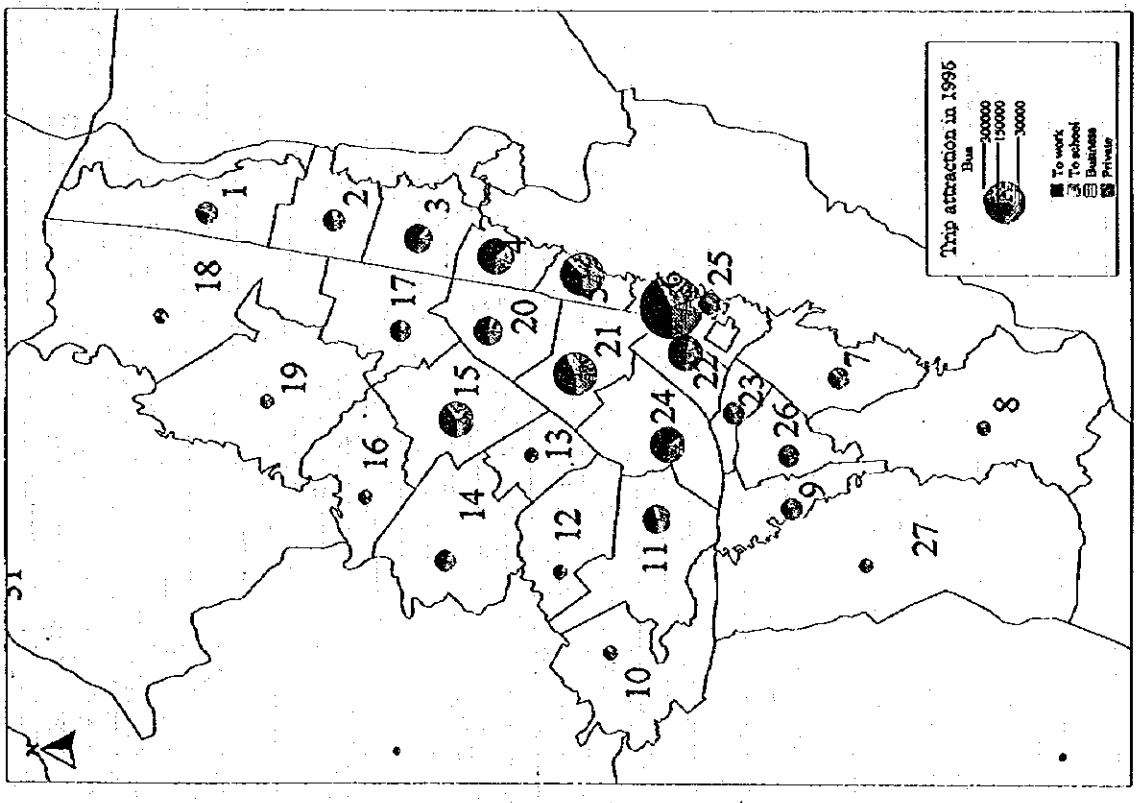


Figure 9.4-3 Trip Attraction by Public Mode (1995/2020)

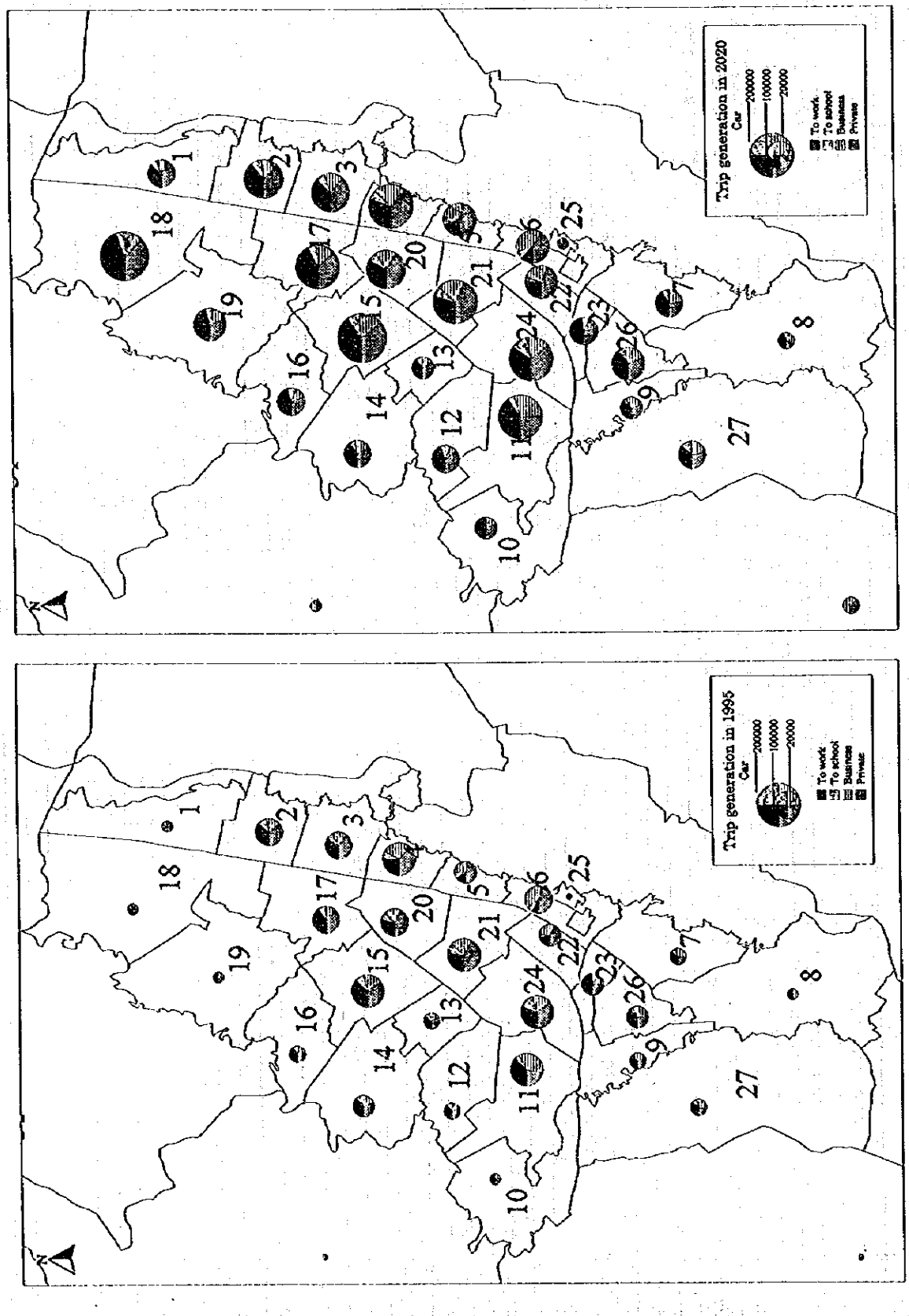


Figure 9.4-4Trip Generation by Private Mode (1995/2020)

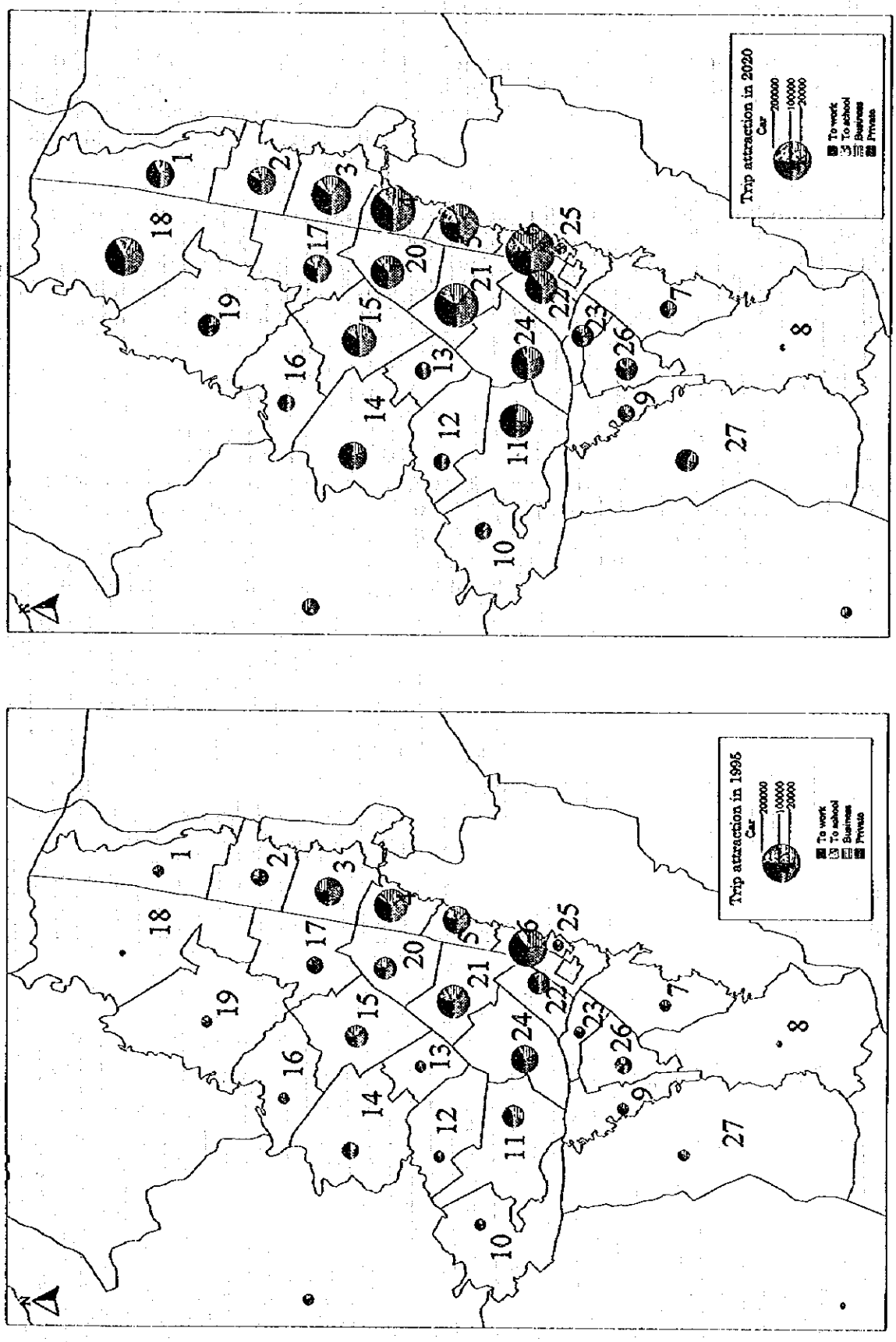


Figure 9.4-5 Trip Attraction by Private Mode (1995/2020)

9.5 Trip Distribution

Figure 9.5-1 illustrates the desire lines by all purposes and modes for interzonal trips in 1995 and 2020. As seen, heavy trip flows in 2020 cover the whole Study Area, and invade into the northern area to a particularly high degree. Compared to the strong desire lines which are predominant within the central area of Bogota in 1995, OD trips in 2020 linked between the central and suburban areas in the fringe of Bogota increase considerably.

The desire lines by the private and public mode are shown in Figure 9.5-2, which also compares the desire lines in 1995 and 2020. In 2020, the desire lines by the private mode strongly cover entire Study Area, while in 1995 they cover only the area within the central area. On the other hand, the public mode links the central business/ commercial area (zone Nos. 5, 6 and 22) and surrounding residential areas with strong desire lines.

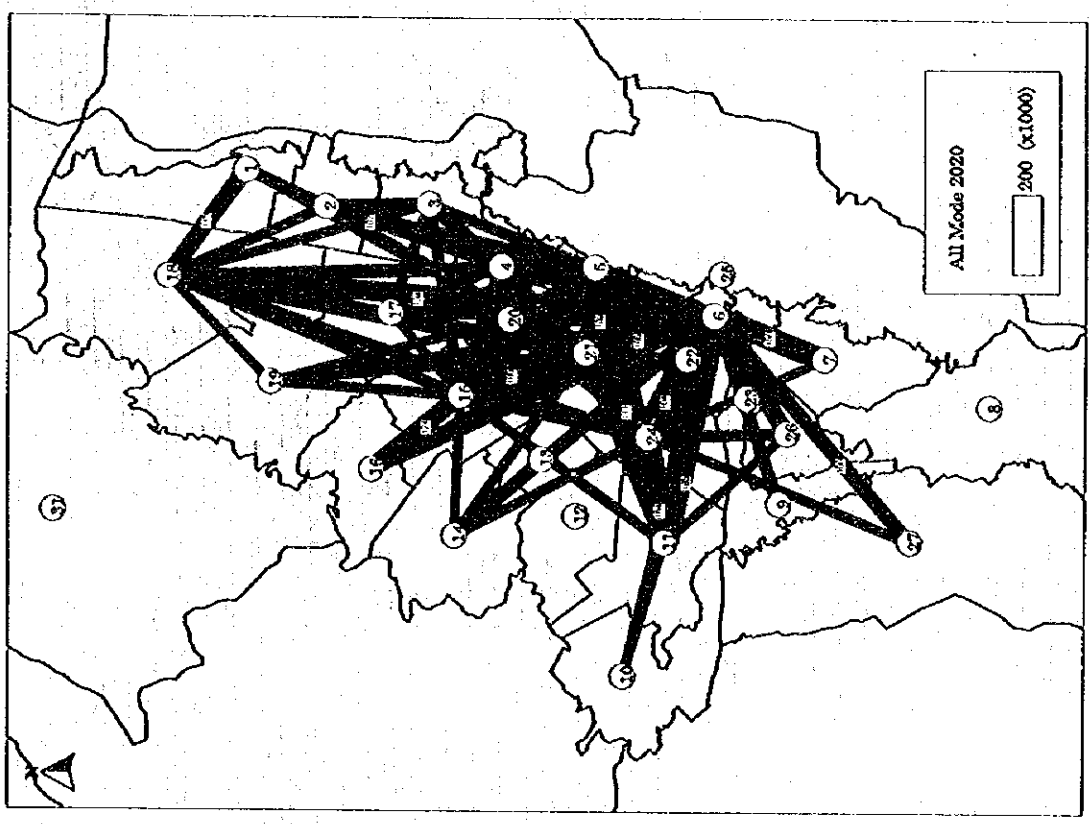
9.6 Modal Split

The number of trips by two modes, public and private transport, is shown in Table 9.6-1. The table shows the number of vehicles calculated from the PT data using vehicle occupancy rate. The rate of increase per unit between 1995 and 2020 is 2.05, while the growth rate of person trips is 1.55. The public and private modes raise at approximately 1.31 and 2.19, respectively. The modal share of public in vehicle trip unit is 10% (494 thousand trips) in 2020, in contrast to 16% (377 thousands) in 1995. The private mode rise from 84% (1.93 million trips) in 1995 to 90% (4.23 millions) in 2020.

Table 9.6-1 Modal Share of Vehicle Trips

(Unit : vehicle per day)

	1995		2020		2020/1995
	No. of Trips	Composition	No. of Trips	Composition	
Private	1,931,032	0.837	4,229,016	0.895	2.19
Public	376,575	0.163	493,577	0.105	1.31
Total	2,307,608	1.000	4,722,593	1.000	2.05



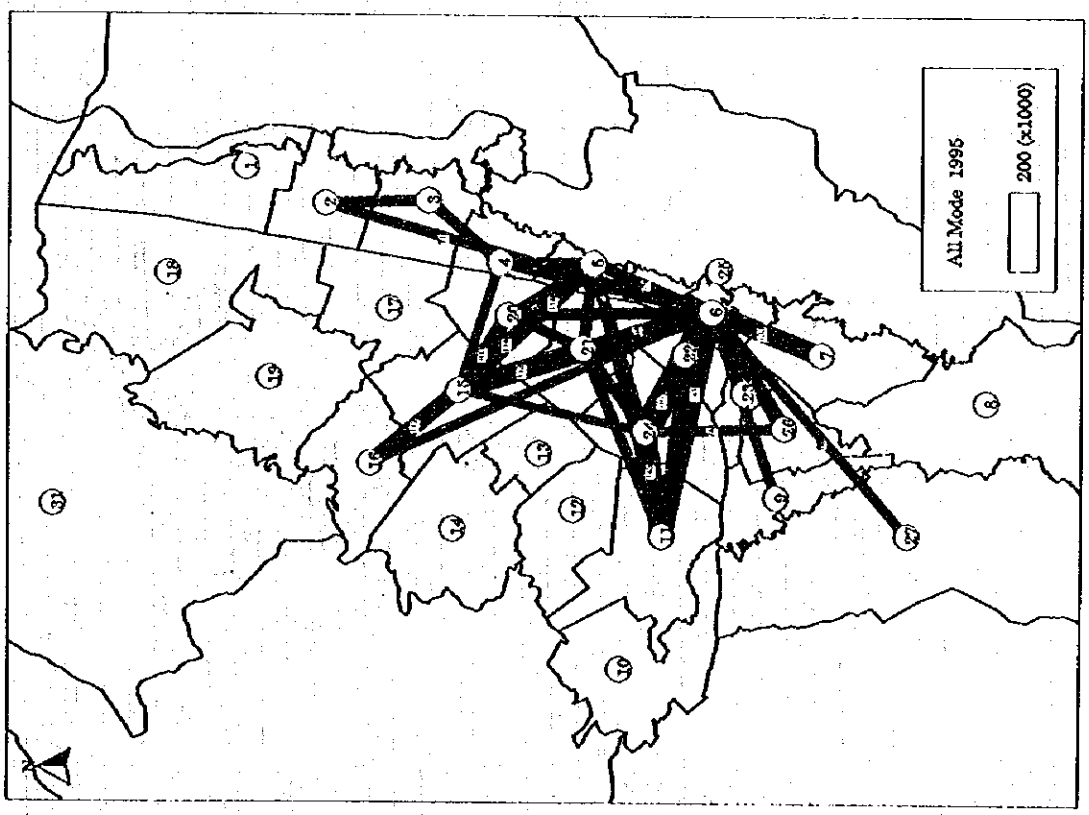


Figure 9.6-1 Trip Desire Line by All Purposes and Modes (1995 /2020)

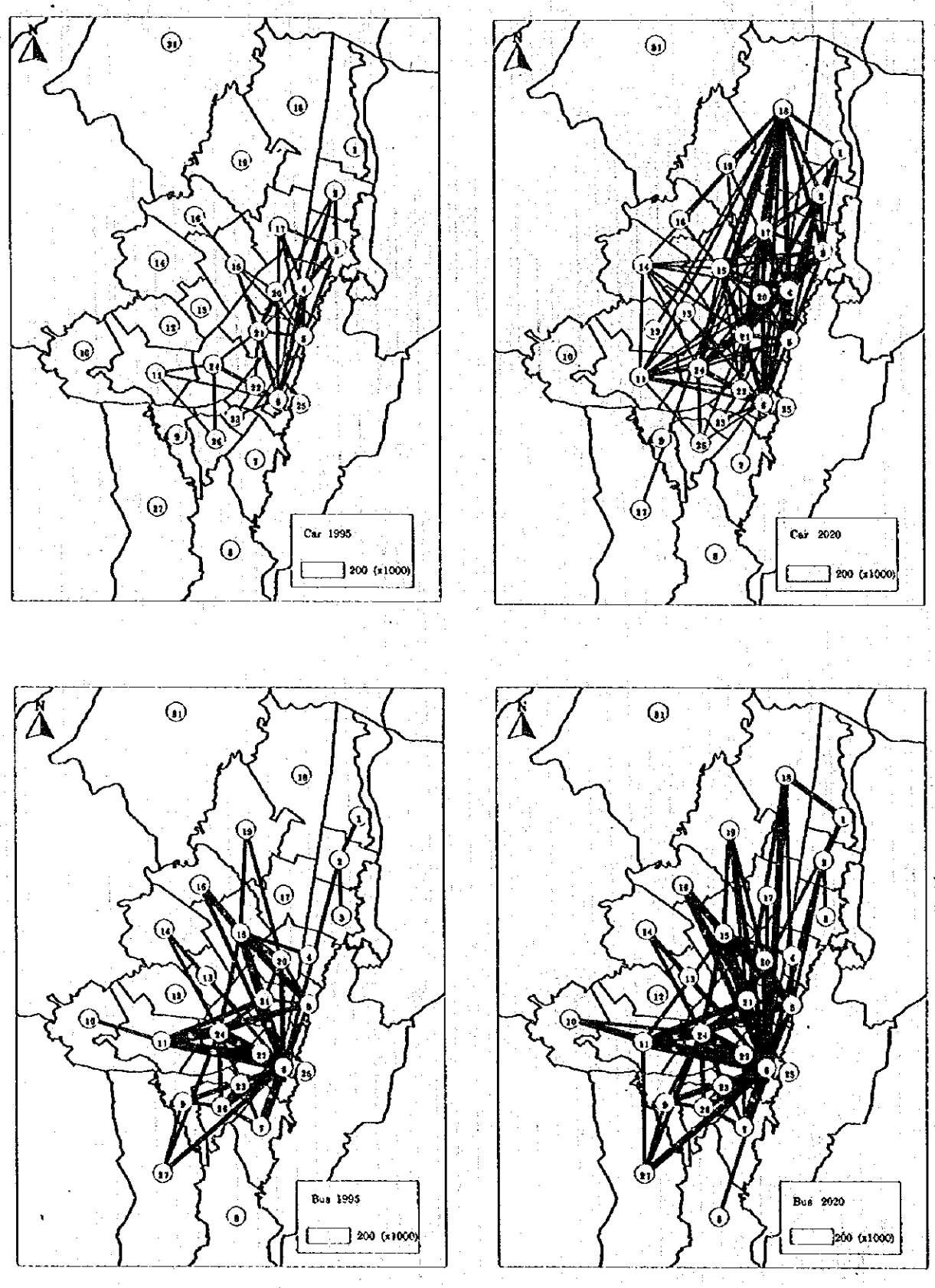
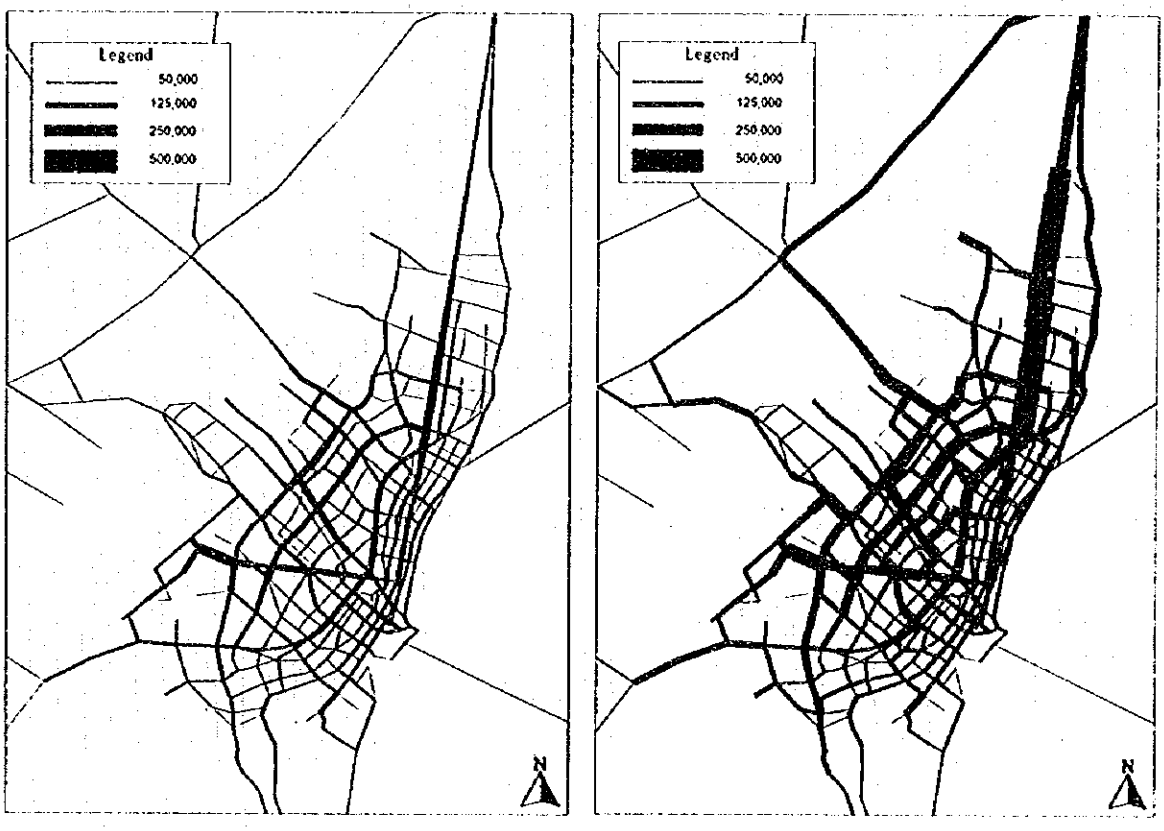


Figure 9.6-2 Trip Desire Line by Public and Private Modes (1995/ 2020)

9.7 Traffic Demand on Road Network

Traffic assignment was made under the conditions on which the OD trips in 2020 loads on the present network to disclose traffic demand on major corridors. The traffic demands in 1995 and 2020 are shown in Figure 9.7-1. In those figures, the traffic volume on each road is drawn by a narrow band whose width is proportional to the assigned traffic volume. When comparing traffic volume in both figures, in 2010, the traffic volume-capacity ratio exceeds 1.0 on almost all the roads. The future traffic conditions will be severe if no improvements are made in the transport network.



[1995] [2020]

Figure 9.7-1 Traffic Demand on Present Road Network in 1995 and 2020

PART III

TRANSPORT MASTER PLAN

CHAPTER 10
Future Transport Network Analysis

10. FUTURE TRANSPORT NETWORK ANALYSIS

10.1 General Planning Consideration

10.1.1 Background of Environment Planning Conditions

(1) Socioeconomic Situation

Annual growth rate of GRDP of Bogota during the 5-year period from 1990 to 1995 was estimated at 4.56% by DANE, and during the 25-year period from 1996 to 2020 it is estimated at 5.0 % by the Study Team. The population in Bogota in 1995 is estimated at about 5.9 million, and its surrounding areas are estimated at about 0.8 million. In 2020 the population of Bogota and its surrounding areas is estimated at 8.6 million and 2.4 million, respectively. The total population of the Bogota Metropolitan Area will reach 11.0 million. The annual population growth rates during the 25-year period from 1996 to 2020 is 1.5% to 1.0% .

(2) Land-Use Characteristics

The existing central business district (CBD) of Bogota is located at the center of old city, but the functions and urban activities of the CBD are gradually shifting toward the northern areas. In addition, urban activities and housing developments pressures are spreading to the northern and western areas rapidly, and commercial areas are also being developed along the existing trunk roads. The development of the urban area is accelerated in accordance with the increasing population in Bogota.

(3) Traffic Demand

In 1995, the total number of person trip movements in Bogota is estimated at about 11 million and in 2020, it is expected to reach 17 million. The traffic volume in 2020 will grow by more than 1.55 times the present traffic volume. Considering the traffic increase and population growth conditions in Bogota, future traffic situations will obviously grow worse. The traffic conditions of existing heavily trafficked areas which are covered by Avenida Ciudad de Quito and Avenida 7a will be especially in grave situation, and the urban activities or functions of this area will not be functional.

(4) Road Facilities

The existing trunk road network pattern in the Study Area is formed by the ring and radial pattern, and the local road network is formed by the grid pattern. However, some road segments of the ring roads are not linked as perfect ring road patterns. There are many potholes in the pavement of almost all the roads, due to poor maintenance of the roads. The major problems of the existing roads are as follows:

a) Inadequacy of the road network and traffic flow system
b) Shortage of the road area (number of roads)
c) Poor maintenance
d) Shortage of grade-separated intersections and signaled intersections

(5) Public Transport

At present, about 75 % of total person trips within the Study Area are carried by public transport such as bus and taxi systems, and about 3% of total person trips use the taxi transport system. There are 865 bus routes authorized in Bogota. In the future, the

percentage of bus users is expected to decrease with increasing car ownership in accordance with increasing income. The major public transport problems are as follows;

a) Lack of functional public transport networks and systems
b) Inadequacy of public transport facilities
c) Weak administration and operation systems
d) Bad driving manners and safety
e) Lack of security

(6) Traffic Management

At present, the traffic circulation system (one-way system), on-street car parking restrictions systems, and signal control system for solving traffic congestion are introduced in the Study Area. However, traffic congestion occurs on many road sections or segments and major intersections. The major traffic problems impeding traffic management are as follows:

a) Large traffic volume
b) Increase of traffic accidents
c) Lack of traffic education (pedestrians and drivers)
d) Nonfunctional intersection facilities

10.1.2 Planning Policy and Strategies

By the year 2020, the population of the Study Area and its surrounding cities will increase to about 8.6 million and 2.4 million respectively, and the urbanization area of Bogota will expand to the urbanization area of the surrounding cities. Urban activities among these cities will be strongly connected, and the Metropolitan Area of Bogota will be formed by Bogota and its surrounding cities.

At present, the actual traffic volume on major ring and radial trunk roads such as Avenida Ciudad de Quito, Avenida Boyaca, Avenida 7a, Calle 68 and Autopista Norte and Sur exceed the capacity. It is easily expected that many roads will overflow, according to the future transport demand forecast. Taking into account the existing transport situation and future expected transport conditions, the following four (4) planning goals or planning policy for the future urban transport system of Bogota are identified by the Study Team.

(1) To Strengthen the Public Transport System

In 1995, about 75% of total person trips were using the public transport system (bus transport). However, in accordance with expansion in socioeconomic activities and increase in personal income in Bogota, the percentage of person trips using the public transport system in 2020 is estimated at about 60 % by JICA Study Team. Increase in the number of passenger cars and decrease in the percentage of public transport users will boost the future traffic volume. Considering the above, a plan to strengthen the public transport should be created to maintain a smooth and safely traffic flows in 2020.

In order to achieve the above mentioned planning policy or planning goal, the following strategies are identified.

a) To ensure a functional operation (fixed time operation)
b) To ensure a comfortable and safety operation
c) To meet a future transport demand
d) To develop a mass-transit system

(2) To Improve the Transport Service Level at Urbanized Area.

Transport service level in the urbanized area today is very weak, and heavy traffic congestion and many traffic accidents have occurred at major intersections or on certain road segments. These traffic conditions will worsen correspondingly with the increasing traffic volume, and furthermore, existing road facilities have no room to widen. A plan to improve traffic service level without any additional land acquisition should be created to mitigate the traffic congestion and to decrease the traffic accidents in the urbanized area.

In order to achieve the above mentioned planning policy or planning goal, the following strategies are identified.

a) To utilize the existing transport facilities in multi-purpose
b) To ensure an adequate traffic management policy
c) To create an adequate public space (good urban environment)
d) To introduce urban expressways

(3) To Create an Adequate Transport Network in Sub-urban Areas

There are very few transport facilities in the existing suburban areas in Bogota. Increased population and brisk socioeconomic activities will make the existing suburb more urbanized. Considering these development activities, an adequate transport network should be developed.

In order to achieve the above mentioned planning goal or policy, the following strategies are identified.

a) To create a road network development plan for a major transport network in the suburban areas.
b) To develop an adequate public transport system
c) To ensure a functional transport facilities

(4) To Develop a Functional Transport System between Bogota and Surrounding Cities.

Importance of transport axes between Bogota and surrounding cities will increase as population and socioeconomic activities grow in the BMA (Bogota and surrounding cities). A functional transport system should be developed between these areas to maintain a smooth and safety traffic flows to meet the future traffic demand.

In order to achieve the above mentioned planning policy or planning goal, the following strategies are identified.

a) To strengthen public transport system on the major radial roads
b) To develop a trunk roads on major radial roads
c) To develop a mass-transit system on major radial roads

10.1.3 Concept of Transport Network Planning

Basically, there are two traffic congestion mitigation measures; one is traffic demand control, and the other is increasing the capacity of transport facilities or transport systems. Traffic demand control is basically maintained by strengthening the public transport system and traffic management aspects, and capacity increase is attained by the improvement or construction of transport facilities.

Taking into account the characteristics and functions of individual transport modes, existing traffic situations, and future traffic demand, the following transport plans are considered for the preparation of an Urban Transport Master Plan.

1) Strengthening the public transport system
   a) To introduce a trunk bus system
   b) To introduce a busway system (Bus Express)
   c) To introduce a railway system
   d) To improve a bus operation system

2) Strengthening the road network system
   a) To improve the existing road network
   b) To construct a new road network

3) Strengthening the traffic management system
   a) To improve the intersections
   b) To develop car parking areas and a car parking system
   c) To improve traffic signs and regulations

10.1.4 Transport Axis to be Developed

Based on the results of the Person Trip survey and its analysis, various traffic surveys, and the future traffic demand forecast, the characteristics of traffic conditions in Bogota were examined. The transport axes to be reinforced is examined in accordance with following viewpoints.

(1) Viewpoint of Trunk Road Network

Basically, the transport axis is formed in accordance with the functions and characteristics of the trunk roads. The trunk road network in Bogota is a ring and radial road network pattern, and these roads are classified as V-0(ROW=100m), V-1(ROW=60m) and V-2 (ROW=40m) roads based on the Colombia Design Standards. The roads of V-0 to V-2 are summarized in Table 10.1-1.

Table 10.1-1 V-0 to V-2 roads in Bogota

Name of Road	Class	ROW	Traffic Volume	Type of Road
a) Autopista Norte	V-0	100	128	Radial
b) Autopista El Dorado	V-0	100	83	Radial
c) Av. De Americas	V-0	100	68	Radial
d) Av. 100 and 68	V-1	60	87-68	Ring
e) Av. Quito	V-1	60	153-103	Ring
f) Av. Boyaca	V-1	60	75-55	Ring
g) Av. Cali	V-1	60	---	Ring
h) Autopista Sur	V-1	60	69	Radial
I) Autopista Medelline	V-1	60	47	Radial
j) Av. Centenario	V-1	60	36	Radial
k) Av. Suba	V-2	40	62-47	Radial
l) Av. 7a	V-2	40	113-43	Radial
m) Av. Cracas	V-2	40	46-39	Radial
n) Av. Mayo	V-2	40	-----	Radial

(2) Viewpoint of Land Use and Population Distribution

Land-use conditions and population distribution situations affect the introduction of any transport system. As a result of the future land-use and population distribution study, the following characteristics are identified.

a) Future population in the existing developed areas which are covered by Avenida Quito and Avenida 7a is stagnant

b) Existing population of Kennedy and Bosa areas in 1995 is estimated at about 1.3 million and future population of these areas in 2020 is estimated at 1.9 million (1.5 times the existing population)
c) Existing population of the Fontibon and Engativa areas in 1995 is estimated at 1.2 million and the future population in 2020 is estimated at 1.5 million (1.25 times the existing population)
d) Existing population of Usaquen and Suba areas in 1995 is estimated at 1.0 million and future population in 2020 is estimated at 2.5 million (2.5 times the existing population) . The trend of increase in population in these areas is rapid.

The above-mentioned characteristics are illustrated in Figure 10.1-1. As shown in the figure, three (3) transport axes are identified; the first is inside centro, the second is center to suburban areas, and the third is suburban areas to outside cities.

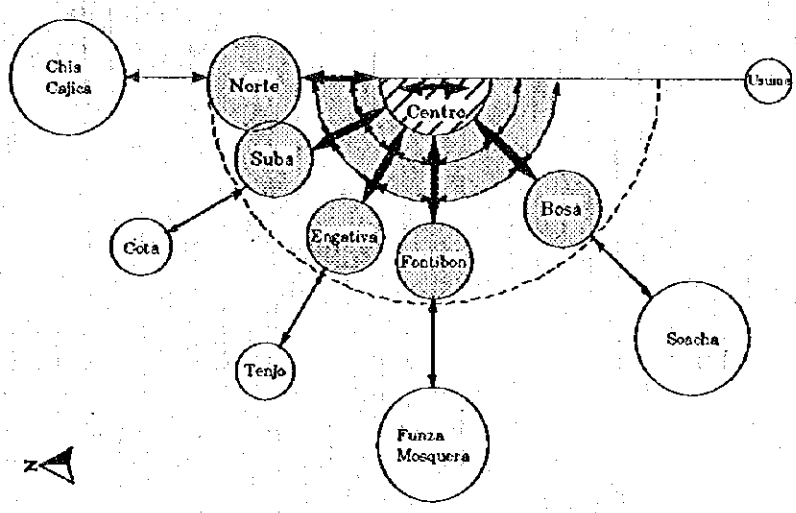


Figure 10.1-1 Characteristics of Population Distribution

(3) Viewpoint of Transport Demand

According to the future transport demand forecast, major traffic flows are concentrated in the central area as well as within the central business area as shown in Figure 10.1-2. Considering the actual traffic volume and capacity of transport mode, the transport network should be developed. The rough capacity of the individual transport system is shown in Table 10.1-2.

Table 10.1-2 Rough Capacity of Individual Transport System

Transport system	Classification	Contents	Capacity
2-lane road	urban area	with signal	10,000 V/D
2-lane road	rural area	without signal	15,000 V/D
4-lane road	urban area	with signal	40,000 V/D
4-lane road	rural area	without signal	60,000 V/D
6-lane road	urban area	with signal	60,000 V/D
6-lane road	rural area	without signal	90,000 V/D
bus exclusive lane	2-lane	100 B /L/H* 30 P*2(signal	6,000 P/H
busway	2-lane	250B/L/H*30P*2(signal)	15,000 P/H
busway	2-lane	500 B/L/H*30P*2 (non signal)	30,000 P/H
busway	4-lane	250B/L/H*30P*4(signal)	30,000 P/H
busway	4-lane	500B/L/H*30*4(non signal)	60,000 P/H
railway	lightrail		more than 50,000 P/H
railway	heavy rail		more than 100,000 P/H

Note; V/D ; vehicles per day and P/H; persons per hour (2-directions)
B; No. of bus. L; No. of lane. H; hour. P; No. of person

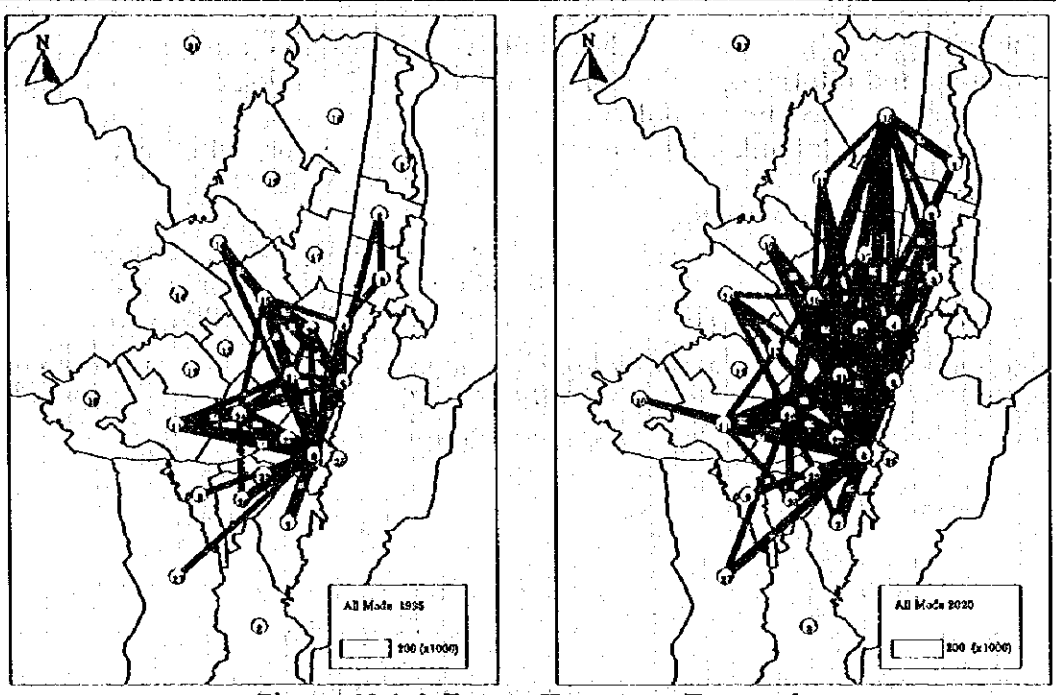


Figure 10.1-2 Future Transport Demand

(4) Viewpoint of Traffic Characteristics

The traffic flow characteristics in Bogota can be divided into three (3) categories; business trips concentrated within the central business district (CBD) covered by Avenida Quito and Avenida 7a; major passenger car trips operating mainly at the northern part; and public transport trip operating mainly at the southern part of Bogota, as shown in Figure 10.1-3.

Considering the above-mentioned situations, it is desired that the transport network plan be based on the three categories; the private transport network developed mainly in northern areas; the public transport network developed mainly in southern areas; and the private and public transport network developed mainly in the traffic congested areas.

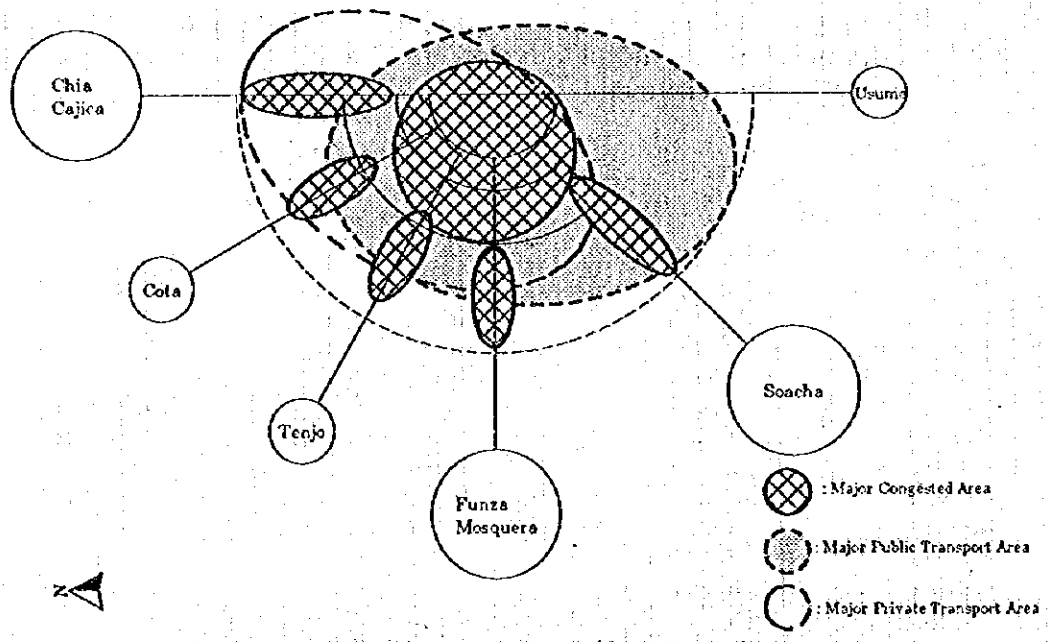


Figure 10.1-3 Traffic Flows Characteristics

(5) Viewpoint of Surrounding Cities

There are several cities outside of Bogota, and these cities can be categorized into five (5) areas, i.e., Chia and Cajica area, Cota area, Tenjo area, Funza and Mosquera area, and Soacha area, taking into account the future population estimated, and socioeconomic situation of the individual city. The population in 1995 of these areas is about 0.8 million, and the population in 2020 is estimated at about 2.4 million (3 times the existing population). As the results of the PT survey, the major OD trips between Bogota city and surrounding cities are shown in Figure 10.1.-4.

Considering the above-mentioned situation, the major transport network between Bogota city and surrounding cities should be developed in accordance with the traffic characteristics between these cities as shown in Figure 10.1-4. The major OD trips from these cities are concentrated in the suburban area in Bogota. Thus, the transport network must be reinforced between these areas.

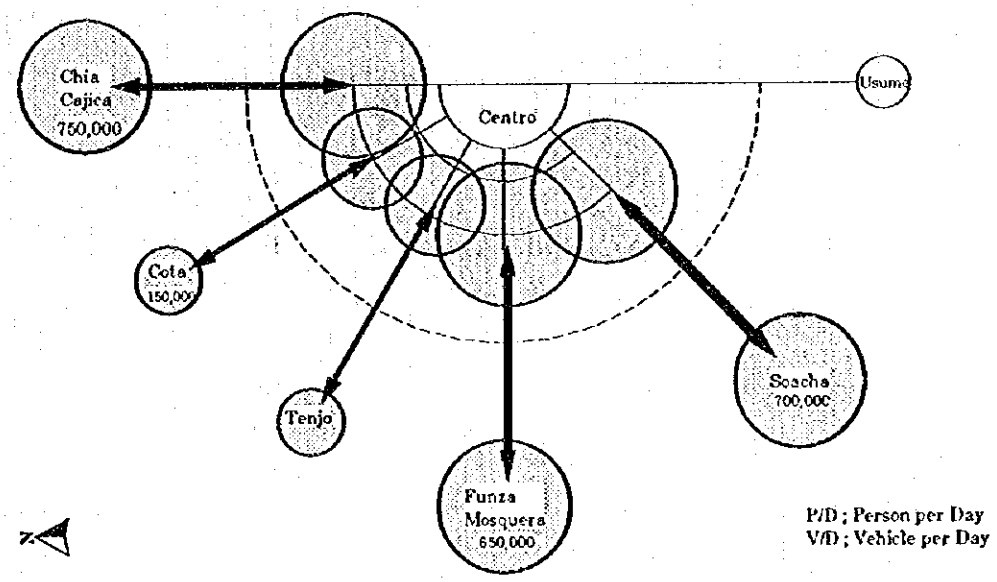


Figure 10.1-4 Traffic Flow between Bogota City and Surrounding Area

(6) Transport Axis to be Developed

Based on the results of the future traffic demand, population distribution, and traffic characteristics, six (6) transport axes to be developed are identified for the important transport systems in Bogota, as shown in Figure 10.1-5.

a) Central Area Axis
b) North Axis
c) Northwest Axis
d) West Axis
e) Southwest Axis
f) South Axis

The transport network development plans are examined based on the above-mentioned transport axis, considering the functions and characteristics of individual transport mode or transport system.

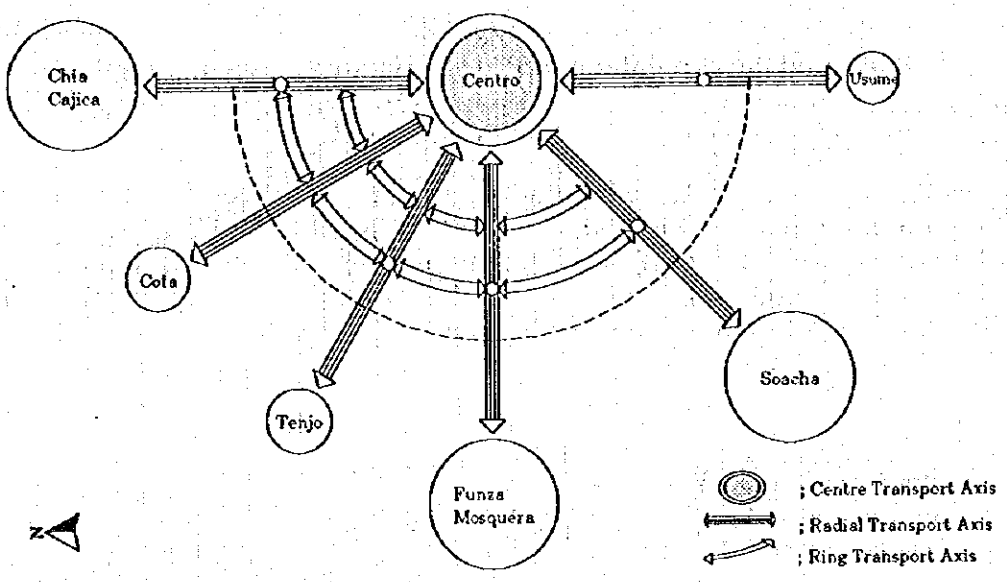


Figure 10.1 -5 Transport Axis of Metropolitan Area

10.2 Road Network Plan

10.2.1 Road Network Planning Conditions

(1) Issues and Problems of Road Planning

The total number of person trip movements in the Study Area in 1995 is calculated at about 11.2 million trips per day, and the person trip movements between Bogota and its surrounding cities is calculated at about 573,000 trips per day. In 2020, these person trip movements are estimated at about 17.4 million.

At present, the traffic on the major roads in Bogota is very heavy, and travel speed is less than 10 km/h during the morning peak hour. In 2020, the traffic conditions in Bogota will worsen and urban activities may not function well. The major problems of existing road facilities and the road network in Bogota are summarized below:

a) Injurious driving manners (car, bus, and pedestrian)
b) Imperfect trunk road networks (missing link)
c) Unsatisfactory intersections
d) Poor road maintenance

The road network development plan is prepared to solve traffic problems as well as maintaining a good urban environment. However, prior to preparing a road network development plan, issues of road development should be identified. Transport surveys and field reconnaissance surveys identified the following three (3) issues and problems of road development.

a) Many transport improvement plans for the solution of traffic problems have been made since 1970. However, these plans have not been implemented yet. When road development plans are prepared, the reasons for this deficiency should be considered.
b) In Bogota, there are many houses and buildings along the roads. It is very difficult to acquire land for implementation of new road construction or widening existing roads. In addition, construction of these projects should be executed while existing traffic continues to operate.
c) In spite of the implementation of road development projects such as new road construction projects or widening of existing roads, the effects of mitigation measures may not be enjoyed due to the bad driving manners. The improvement of education for traffic manners should be directed to ensure good urban environmental aspects and decrease traffic accidents.

(2) Functions and Characteristics of a Road

The road network development plan is directed in accordance with the functions and characteristics of a road. It is very important to identify the functions and characteristics of an individual road.

1) Road-Function Classification

According to a Policy on the Geometric Design of Highways and Streets specified by the American Design Standards, a road-function classification in urban areas is divided into the five (5) categories listed below:

a) Freeway
b) Principal arterial
c) Minor arterial

d) Collector
e) Local road

Colombia has her own design standard. According to these Design Standards, road-function classifications are divided into two (2) categories; arterial road and local road. The arterial road is divided into seven (7) classes and the local road is divided into eight (8) classes, as listed below;

- Arterial Roads
  a) V-0 Road ROW=100m
  b) V-1 Road ROW= 60m
  c) V-1P Road ROW=60m
  d) V-2 Road ROW=40m
  e) V-3 Road ROW=30m
  f) V-3E Road ROW=25m
  g) V-3R Road ROW=18m

- Local Roads
  a) V-4 Road- ROW=25m
  b) V-4A Road ROW=22m
  c) V-5 Road ROW=18m
  d) V-6 Road ROW=16m
  e) V-7 Road ROW=13m
  f) V-8 Road ROW=10m
  g) V-9 Road ROW=8m
  h) V-9E Road ROW=6m

2) Road Functions and Characteristics

The functions and characteristics of each classified road are examined for formulation of a road network plan in the Study Area. The road functions and characteristics are summarized in Figure 10.2-1. According to this Figure, the following matters can be described.

a) Urban freeways and arterial roads are required primarily for maintaining mobility and high road standards or criteria.
b) Local roads and collector roads are required primarily for maintaining land access and low design criteria.
c) Collector roads are situated between arterial roads and local roads.

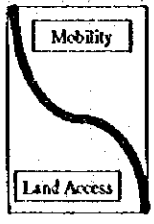
Function Of Road	Characteristics Of Road Traffic					Class of Road	Remarks
	Traffic Volume	Trip Length	Travel Speed	Mode of Trans-portation	Trip Purpose		
	Heavy Low	Long Short	High Low	Motor Vehicle Motor Cycle Bicycle Foot	Business to Work To School Shopping	Arterial Road Collecter Road Local Road	

Figure 10.2-1 Function and Characteristics of Road

The main and subordinate functions and characteristics of roads are summarized in Figure 10.2.-2. According to this Figure, the following matters can be described.

a) Urban freeways and arterial roads are to be saved mainly for long- or comparatively long-distance trips with high traffic capacity and high travel speed.
b) Local roads are mainly for short-distance trips with small traffic capacity and low travel speeds.
c) Collector roads are situated between arterial and local roads.

	Network Characteristics				Traffic Characteristics								
	Link City to City	from Community	Within Community	Access to Housing	Trip Length			Capacity			Travel Speed		
					Long	Middle	Short	Large	Middle	Small	High	Middle	Low
Urban Expressway		O	Δ		Δ	O		O			O		
Principal Arterial Road	O	Δ			O	O		O			O	Δ	
Minor Arterial Road		O	Δ			O	Δ		O			O	Δ
Collector Road			O	Δ		O	O		O	Δ		O	Δ
Local Road				O						O			O

O: Main Function

Δ: Subordinate Function

Figure 10.2-2 Road Characteristics of Individual Roads

Considering the functions and characteristics of the above-mentioned roads, relationship between the road classification of Colombian Standards and American Standards can be identified as follows:

a) V-0 Road Freeway
b) V-1 Road Principal Arterial Road
c) V-2 Road Minor Arterial Road
d) V-3 Road Principal Collector Road
e) V-4 to V-5 Road Minor Collector Road
f) V-6 to V-9 Road Local Road

(3) Road Class to be Planned

As mentioned above, the road classes in Colombia are divided into fifteen (15) types; that is seven(7) types of arterial roads and eight (8) types of local roads. Taking into account the objectives and situations of the Study, the road network plan is conceived based on the V-0, V-1, V-2 and V-3 roads in the Study.

The road network system must not only contribute to the development of urban activities but also form the basic urban structure. In addition, the road network system arrangement must contribute to the socioeconomic development of the city. The road network system is completed by the arterial, collector, and local roads. It is very important to construct collector and local roads taking into account the basic function and characteristics of road network system. Generally, collector roads and local roads will be constructed in accordance with the progress of development, and the planning of the road network will be concurrent with the development. However, considering the importance of local road network, the guidelines of local road planning are examined in Chapter 11.6.

10.2.2 Future Traffic Volume Assignment on the Existing Road Network

The future traffic projection in 2020 was forecast in the previous chapter. The assignment of traffic volume in 1995 and 2020 on the major existing road network is illustrated in Figure 10.2-3. According to this figure, the following matters are pointed out.

1) The traffic volume on major ring roads such as Avenida Quito, Calle 100 & 68 and Avenida Boyaca exceeds the capacity.

2) The traffic volume on major radial roads such as Avenida 7a, Autopista Norte, Autopista Medellin, Avenida Centenario, and Autopista Sur exceeds the capacity.

3) The traffic volume on V-3 roads also exceeds the traffic capacity.

4) Avenida Suba, Avenida Centenario and Autopista Sur have especially heavy traffic.

5) From the viewpoint of the above-mentioned matters, the construction of new roads are required in the suburban area of Bogota, and the existing trunk radial and ring roads should be improved.

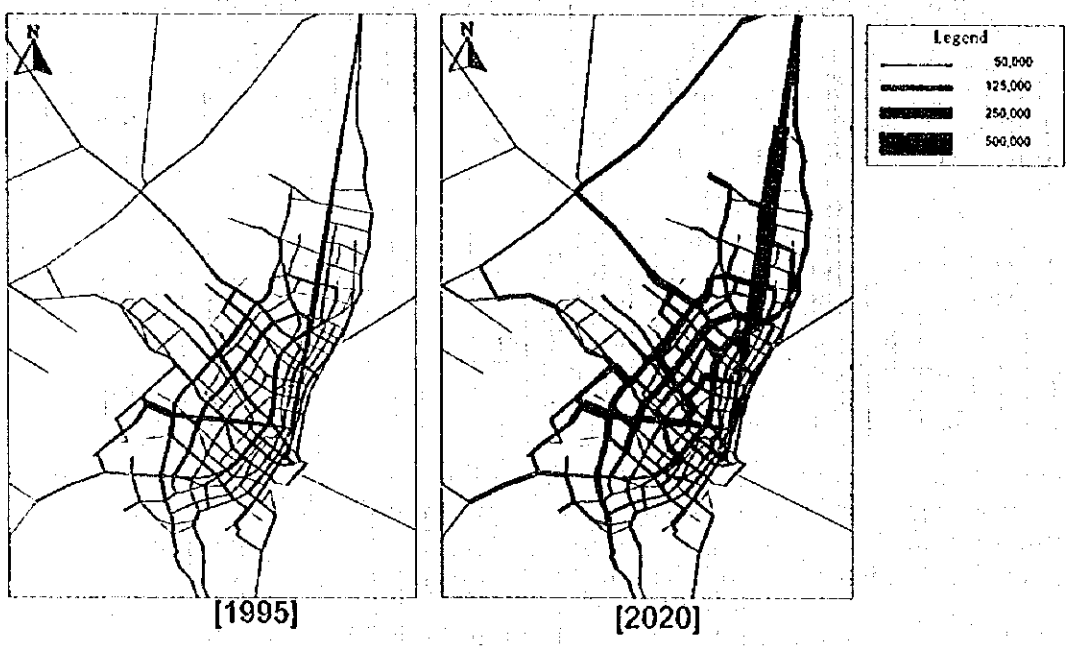


Figure 10.2-3 Future Traffic Volume Assignment on Existing Major Roads

10.2.3 Road Network Development Conceptual Plan

Based on the analysis of the above-mentioned matters, the road network conceptual plan is identified as shown in Figure 10.2-4. The major road network planning concept in Bogota is identified taking into account the existing road network, the function and characteristics of a road, future socioeconomic conditions, and the future land-use plan. The major concepts are as follows.

1) Basically, a ring and radial road network pattern is adopted as a future road network in Bogota, taking into account the existing road network pattern and future land-use conditions.

2) Route locations of V-0 or V-1 roads and V-2 and V-3 roads are arranged in accordance with the road hierarchies.

3) The types of intersections between trunk road or local road are adopted in accordance with the functions and characteristics of the respective roads.

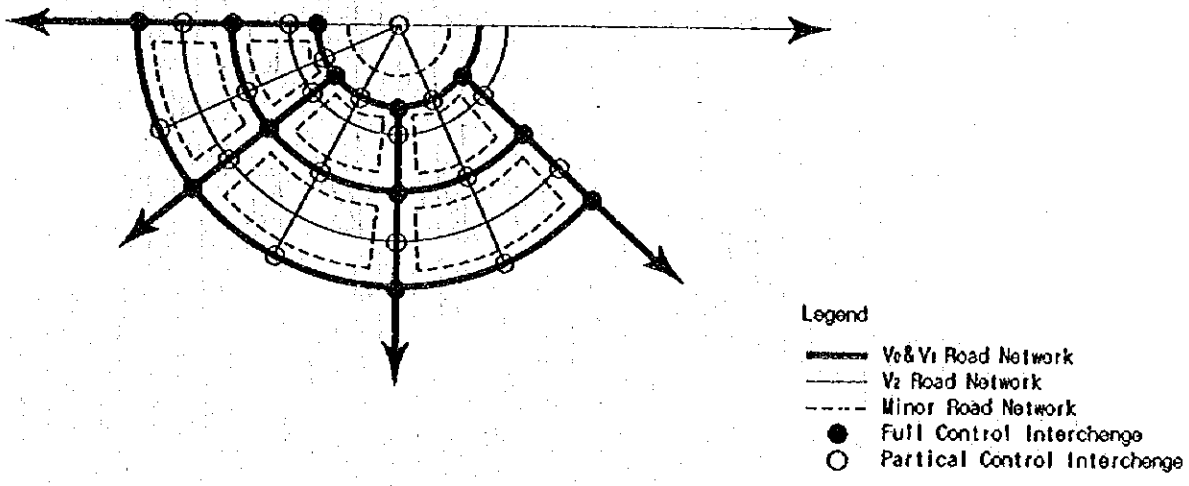


Figure 10.2-4 Road Network System Configuration

10.2.4 Road Network Development Planning

(1) Basic Future Road Network

Since 1980, the road network development plans have been examined by the DAPD, and the future road network development plan in Bogota was identified in the Acuerdo 2 -1980. Based on this Acuerdo, the road network has been improving gradually. In 1990, the Acuerdo 2-1980 was updated as the Acuerdo 6-1990 (Acuerdo del Concejo Distriatal No. 6 de 1990). The Acuerdo 6-1990 is road network plan authorized by the Municipality of Bogota which alteration rests with the mayor. Thus, the Acuerdo 6-1990 shown in Figure 10.2-5 is adopted for the basic future road network in the Study.

This basic road network mentioned above is formed by V-0, V-1, V-2, and V-3 roads, and the major new roads being planned will be concentrated in new development areas. However, the following two (2) aspects should be re-considered in accordance with the changing socioeconomic activities of Bogota and its surrounding cities.

a) The Road network configuration between Bogota and its surrounding cities should be reconsidered.
b) The Road network should be reconsidered according to road hierarchies such as V-0, V-1, V-2, and V-3.

In accordance with Acuerdo 6-1990, the future road network is formed by road class V-0 to V-3 roads, and the following road development projects are identified as the major trunk road network in Bogota.

1) For Existing Road Improvement Plan
   a) Expreso Norte- Quito- Sur (Calle 30)-------V-1
   b) Expreso Norte- Occidente-Sur (Avenida Boyaca)---------V-1

2) New Road Development Plan
   a) Expreso Avenida Ciudad de Cali----------V-2
   b) Avenida Longitudinal de Occidente--------V-0

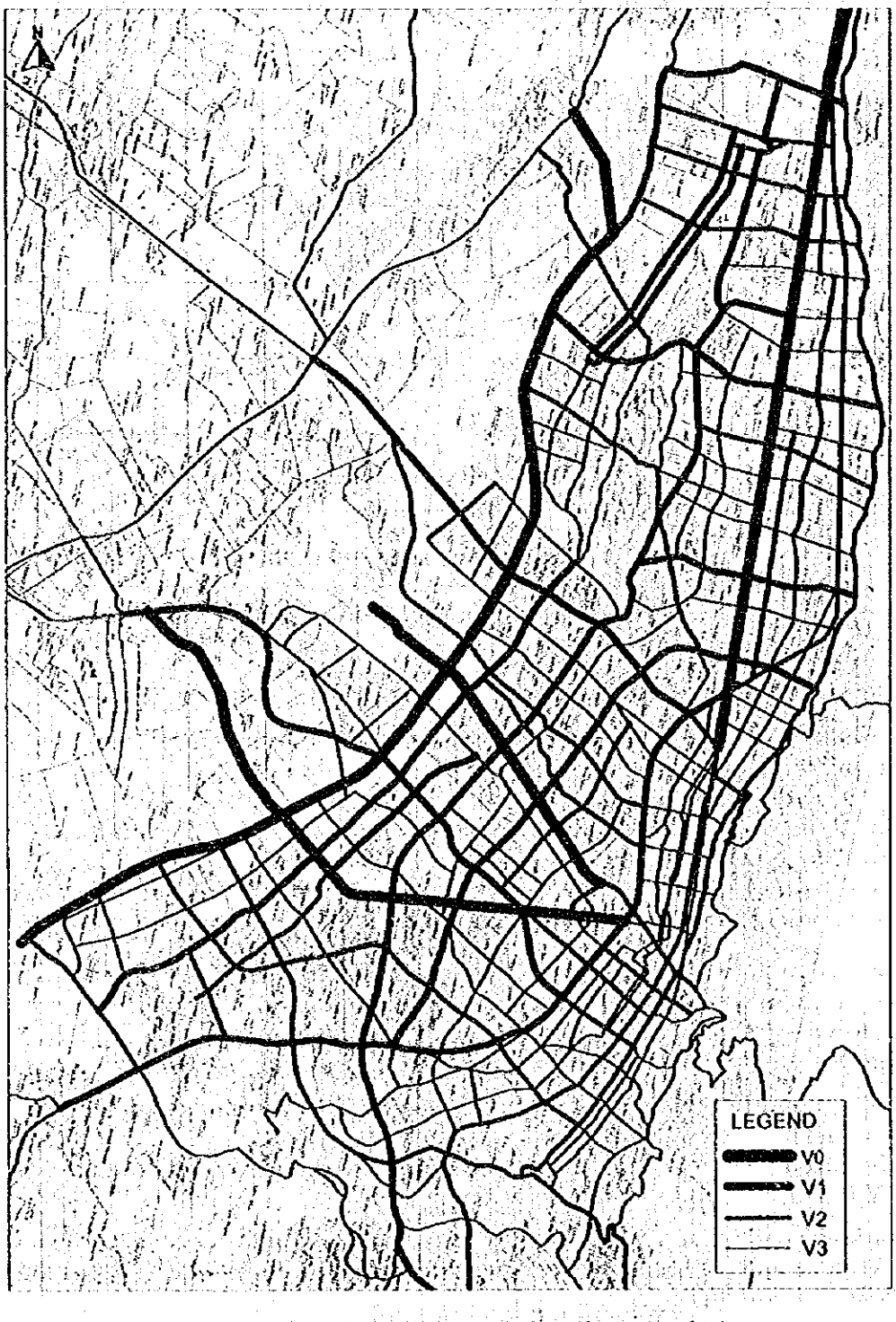


Figure 10.2-5 Basic Future Road Network

(2) Future Traffic Volume on Basic Future Road Network

The future traffic volume in the year 2020 is assigned to the basic future road network as shown in Figure 10.2-6.

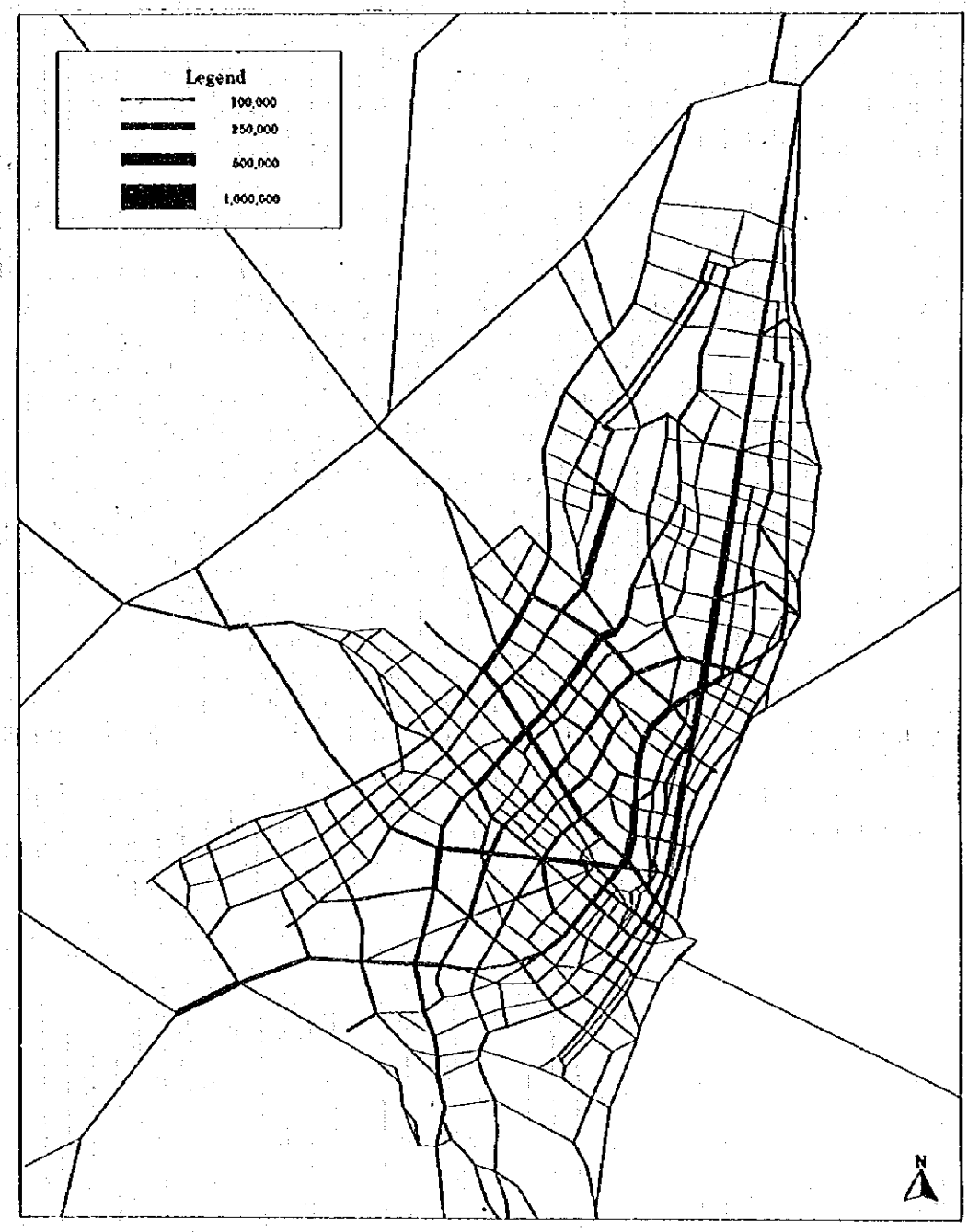


Figure 10.2-6 Future Traffic Volume Assignment on Basic Future Road Network

(3) Road Network Alternative Plans

The road network alternative plans are examined in accordance with the planning guideline, future land-use plan, existing road network, and future traffic demand forecast. Considering these matters, two (2) road network alternative plans; Alternative Plan R-1 and Alternative Plan R-2, are identified as shown in Figure 10.2-7 and 10.2-8, respectively.

1) Alternative Road Network Plan R-1 (see Figure 10.2-7)

Alternative R-1 Plan is identified as a modification road network plan based on the road network prepared by the DAPD. The major routes modified are as follows:

a) Expansion of Avenida de las Americas(V-0) directly connecting to the Avenida Cundinamarca(V-0).
b) Expansion of Avenida Jose Celestino Mutis (V-2) directly connecting to the Sabana Road(V-0).
c) Avenida Boyaca (V-1) has to be maintained to keep the function of a ring road to connect to the Avenida Rodrigo Lara Bonilla(V-2) and Avenida Callejas(V-3), and the class of road should be changed to that of a V-1 road.
d) Avenida Cuidad de Cali (V-2) has to be maintained to keep the function of a ring road connecting to the Avenida San Jose(V-1), and the classification of Avenida San Jose should be changed to that of a V-2 road.

2) Alternative Road Network Plan R-2 (see Figure 10.2-8)

Alternative Road Network Plan R-2 is combination of Alternative Road Network Plan R-1 and Urban Expressway Network. Urban Expressway network is formed by two (2) ring roads and four (4) radial urban expressway plans as shown below:

a) First Ring Urban Expressway Plan(Calle 72 and Avenida Quito)
b) Second Ring Urban Expressway(Calle 100 and Calle 68)
c) Avenida 7a Radial Urban Expressway Plan (Avenida 7a)
d) Autopista Medellin Urban Expressway Plan (Rio Amarillo or Autopista Medellin)
e) Autopista El Dorado
f) Avenida de las Americas

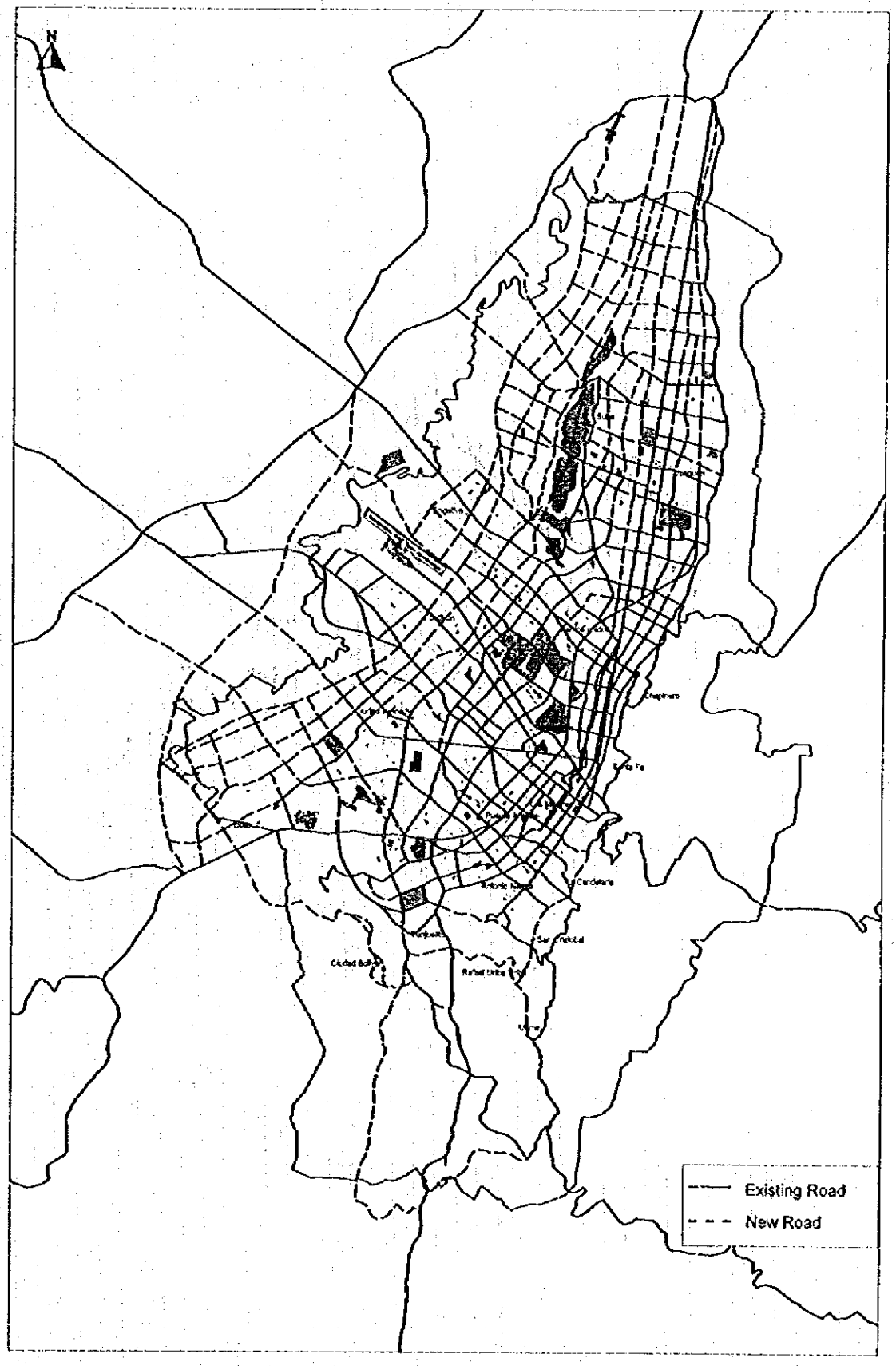


Figure 10.2-7 Locations of Road Network on R-1

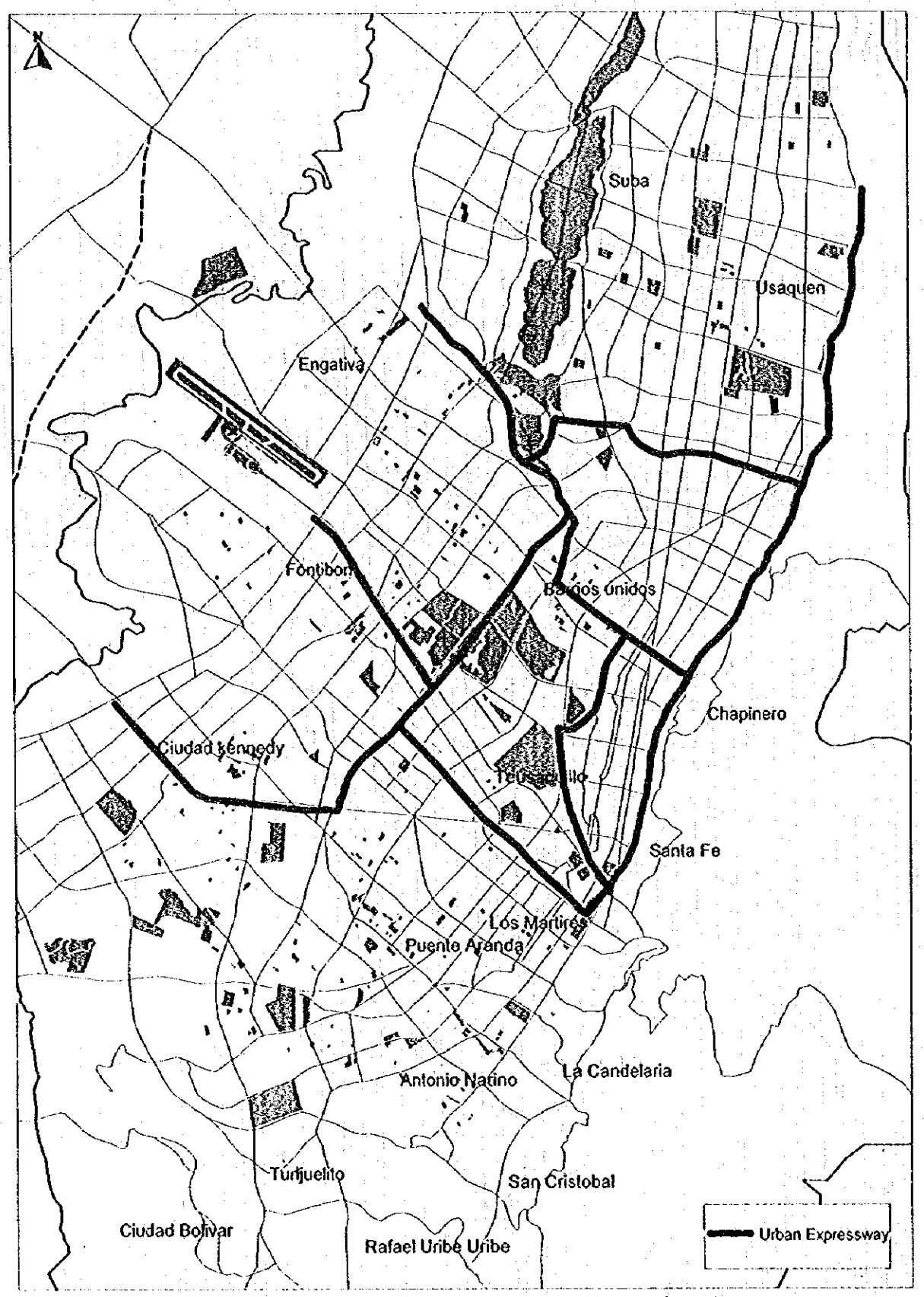


Figure 10.2-8 Locations of Urban Expressway Network

10.3 Public Transport Network Plan

10.3.1 Planning Approach

Long-term perspectives on the public transport network will be explained in this section, to develop a network as the basis of the Master Plan. Although the trunk bus and feeder bus system proposed in Chapter 12 as short-term measures should survive also in the long-run, the network to be discussed here is limited only to a network of mass-transit with a daily capacity of over 500,000 passengers in both directions. The mass-transit system in this sense does not include such systems with medium-sized capacity like the street-car, monorail or light rail transit, but a heavy rail system or an express bus system with exclusive busways.

The mass-transit network dealt with here is not necessarily the target to be met by the year 2020, but the ultimate goal in the foreseeable future. Even if the urban railway system to be built within the coming 25 years is one line or two at most, it is absolutely necessary to plan a master plan network using a comprehensive approach, in order to build a network well-balanced in geographical distribution and consistent with a land use plan.

Alternatives are prepared based on the following conditions and information.

a) To identify available space to accommodate a railway line (over 8 meters in width).
b) To check the potential demand on the space or parallel road.
c) To review the land use plan in the influenced area along a candidate corridor.
d) To compose an alternative network referring to the outstanding OD pairs and network plans proposed in the past.
e) To make a network of approximately 100 km in total extension.
f) To not consider much of the location of car depots and environmental impact at this stage.

10.3.2 Candidate Routes

(1) Public Transport Demand, 2020

Public Transport demand is forecasted to increase 1.35 times from 8.3 million passengers per day in 1995 to 11.2 million passengers in 2020. Figure 10.3-1 presents future volume of passenger flows assigned to the present road network by all-or-nothing method, which shows the potential demand on each link.

Outstanding flows of over one million passengers are observed on Autopista del Norte, Avenida Caracas, the southern half of Avenida Ciudad de Quito, and Avenida Boyaca, followed by Autopista del Sur (500,000-800,000 passengers), Avenida Centenario (600,000-700,000 passengers) and Calle 81 (400,000 - 800,000 passengers).

(2) Frequently Proposed Route

In the past 25 years, many studies has been made on mass-transit networks for Bogota, of which main ones and recent ones are shown in Figure 10.3-2. Twelve proposed networks overlap, and for each link we counted how many times it is designated as a mass-transit route in those network plans. The result is shown in Figure 10.3-3. It does not necessarily mean that a link taken up many times is important. However, frequently appearing link may have proper reasons.

In the north-south direction, many proposals focus on the route of Avenida 13 Sur starting from El Socorro, Avenida Caracas and Autopista del Norte. Several proposals recommend the north-south route of Autopista del Sur - Avenida Ciudad de Quito - the north railway line, using space of the railway after Avenida Ciudad de Quito.

Another route using the railway space is the north line and the south line connected by a link passing El Salitre Park and Carrera 50.

In radial directions, several routes are highlighted such as Autopista del Sur, Avenida de las Americas, Avenida Centenario, Autopista El Drado, etc. and the west line and the south line of railways, as well. Autopista Medellin is also proposed as a Corridor from the northern business center in Chapinero to the west.

The following two routes are proposed as circumference routes:

a) Avenida Boyaca -Carrera 72 -Avenida 127 - Avenida 7 - Carrera 10 - Avenida Boyaca
b) Avenida 68 - Calle 100 - Avenida 7 - Carrera 10 - Autopista del Sur (or Avenida 27) - Avenida 68

(3) Candidate Routes

A mass-transit network is composed of several routes. Thus possible routes should be listed before planning a network. The following arteries are promising and suitable to accommodate a mass-transit route, according to the conditions stated in Chapter 10.3.1.

a) Autopista del Norte
b) Avenida Caracas
c) Autopista del Sur
d) Avenida Ciudad de Quito
e) Avenida Boyaca
f) Avenida 68/ Avenida General Santander/ Avenida El Espectador
g) Avenida 1o de Mayo
h) Avenida Centenario
i) Avenida Las Americas
j) Autopista El Dorado
k) Avenida 81
l) Avenida Suba
m) Avenida 127
n) Calle 6
o) Avenida 19/ Avenida Santa Barbara

In general, urban space other than road space often used for a mass-transit route is existing railway space and a river/canal. In the case of Bogota, three railway lines (north, west and south lines) have been repeatedly proposed as spaces for a new railway system. Although the west line and the north line are still under operation, their spaces will became available in the future. On the other hand, rivers in Bogota wind through the city and are not convenient for accommodating a mass-transit system, except on the canal along Avenida Ciudad de Quito.

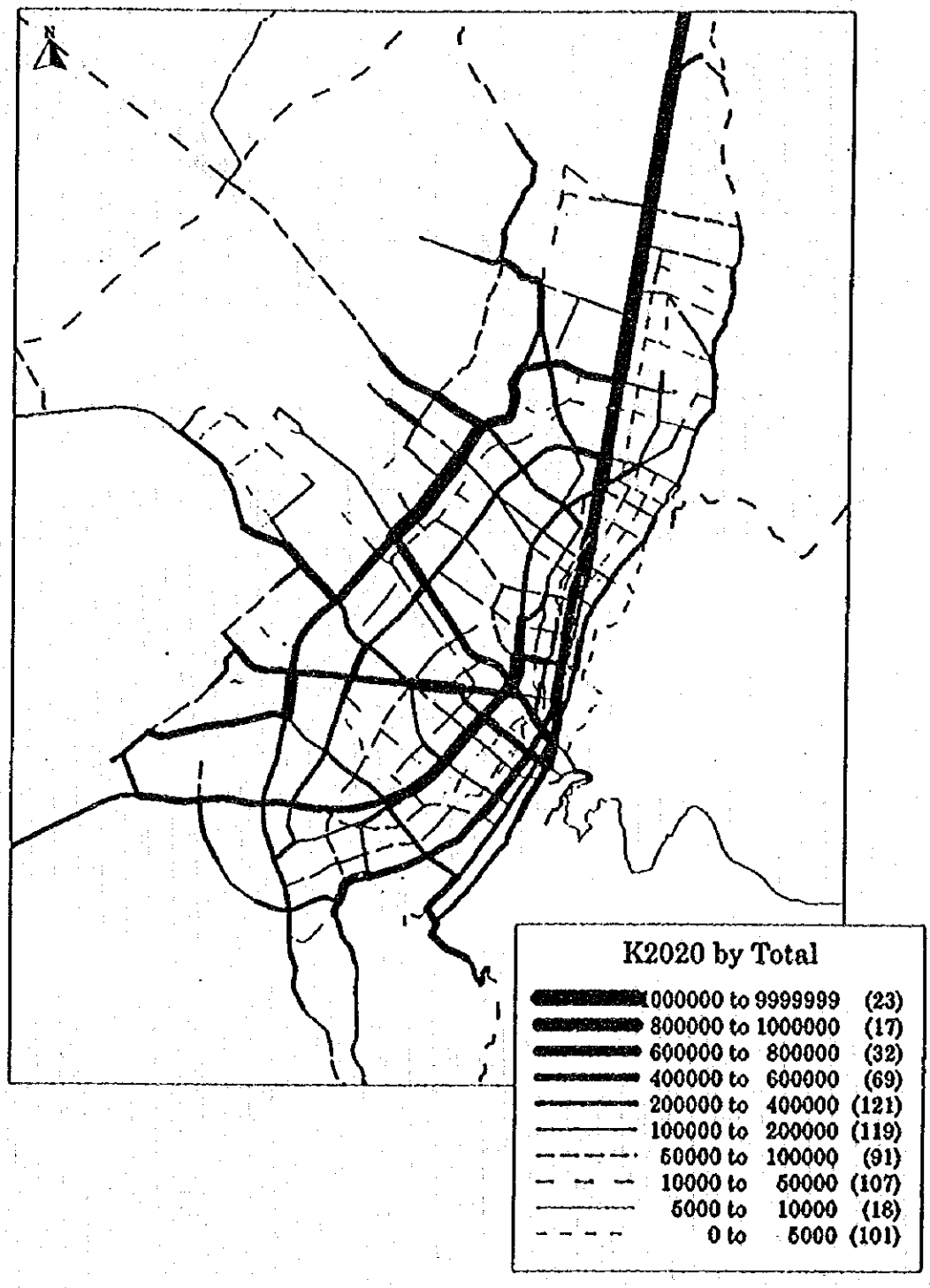
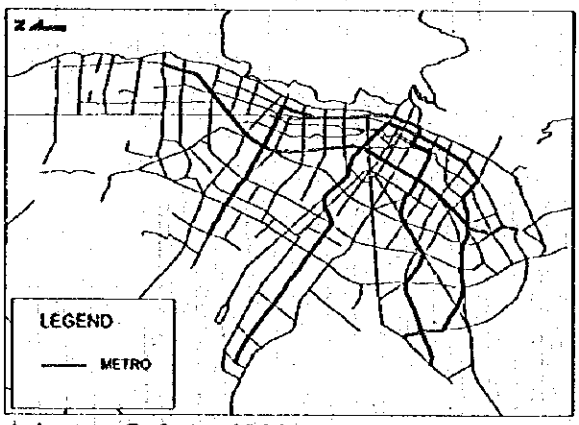
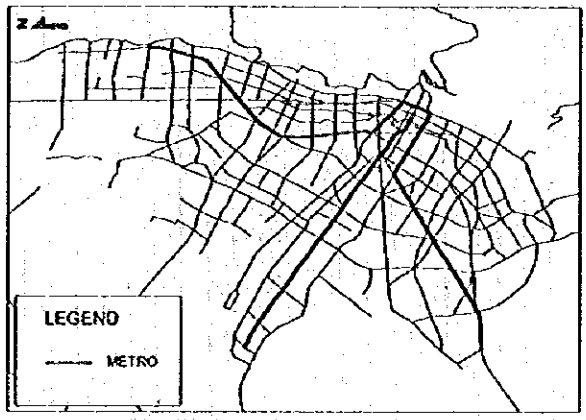


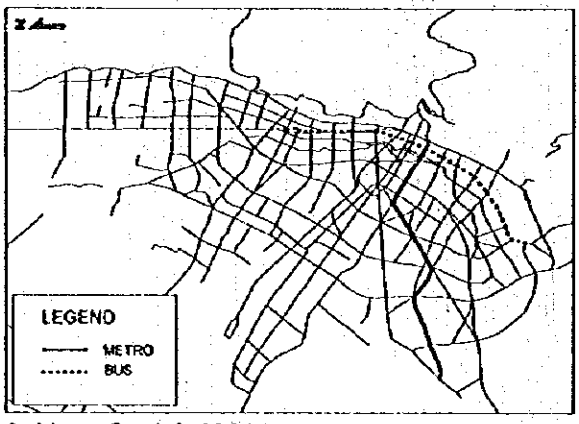
Figure 10.3-1 Potential Demand for Public Transport in 2020



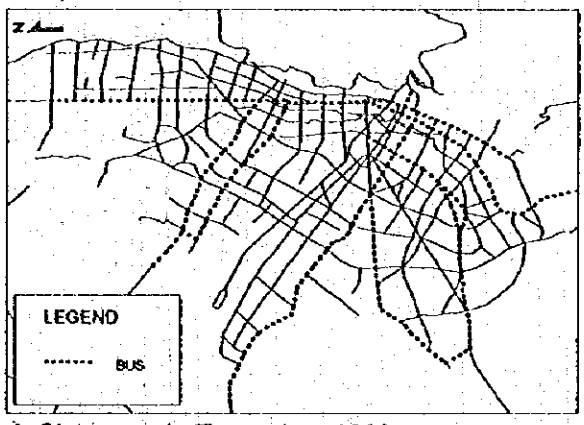
1. Ineco - Sofretu, 1981



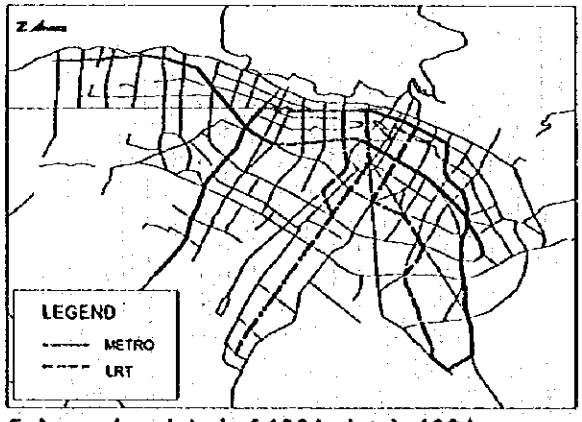
2. Intermetro SPA, 1988



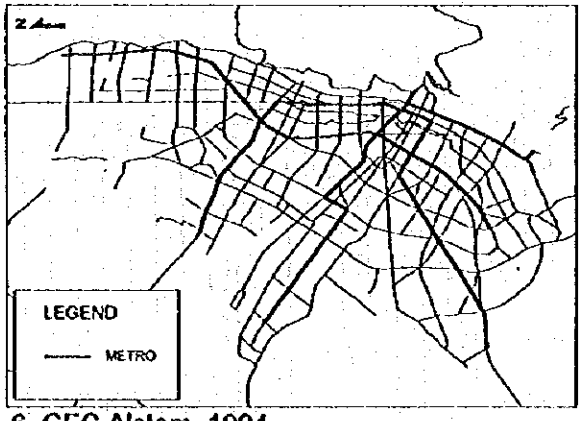
3. Linea Social, 1990



4. Sistemas de Troncales, 1990

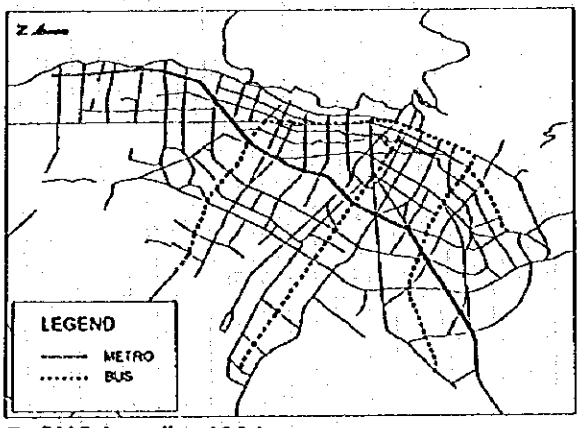


5. Ineco (updated of 1981 plan), 1991

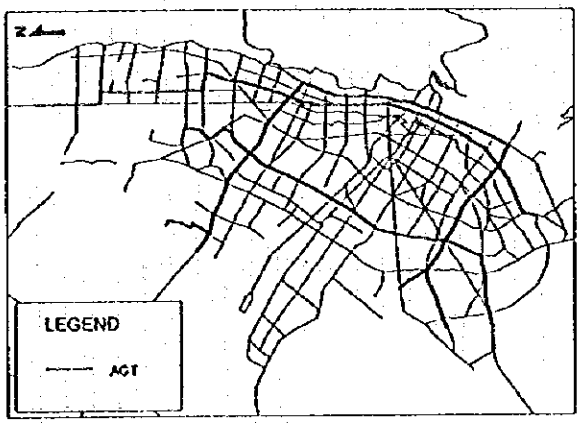


6. GEC Alstom, 1994

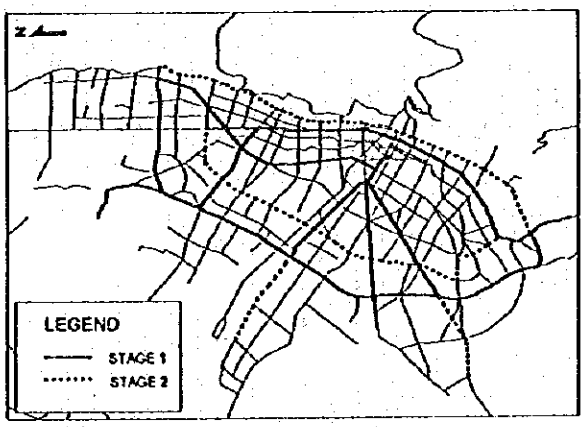
Figure 10-3-2 Mass-transit networks proposed in the past Studies



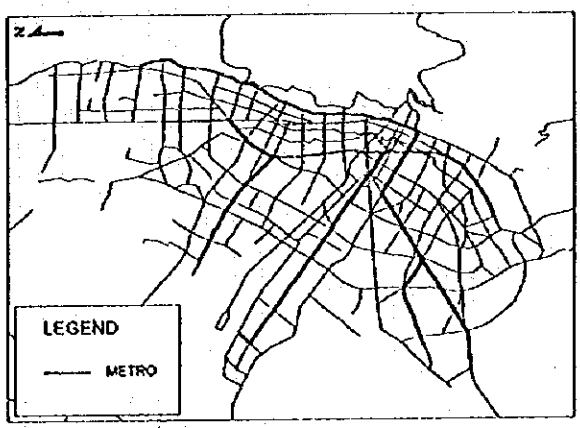
7. SNC Lavalin, 1994



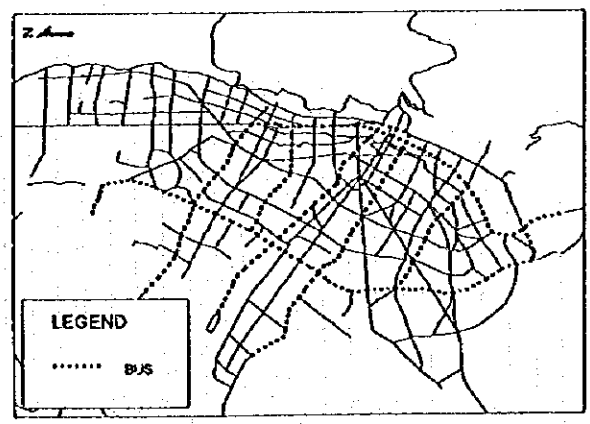
8. Metrovias Bogota, 1994



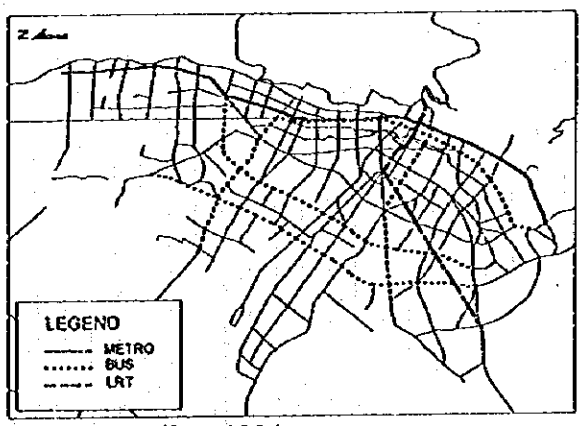
9. SMB (Metrobus System), 1994



10. Siemens, 1994



11. Unibus, 1994



12. Halcrow Fox, 1994

Figure 10-3-2 Mass-transit networks proposed in the past Studies (Cont'd)

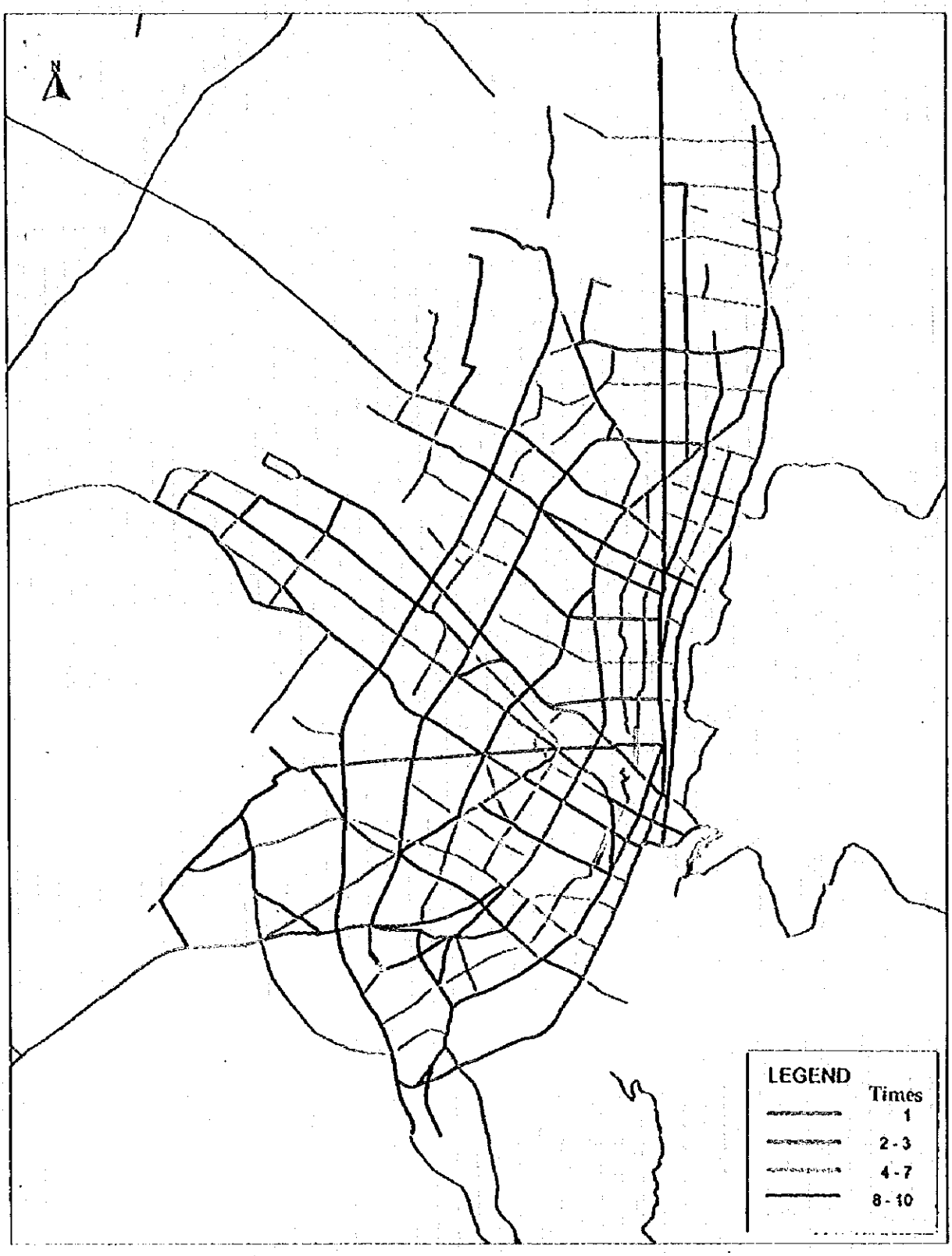


Figure 10-3-3 Links Frequently Designated as Mass-Transit Routes

10.3.3 Alternative Networks for Mass-Transit

Four alternatives are set up as shown in Figure 10.3-4. Alternative A is mainly based on the network of INECO-SOFRETU and INECO. Alternative B is similar to the network of HALCROW FOX. Alternative C emphasizes serving the area of Suba and its north, where dense development is expected in the future. Alternative D is a combination of a circular line and radial lines.

10.3.4 Evaluation and Selection

Preliminary evaluation was made on the alternative networks of mass-transit (rail transit) from the viewpoint of potential demand. For each alternative network, total potential demand is calculated in terms of passenger-km and also average passenger density, shown in Table 10.3-1.

Alternatives A and B have higher potential demand than the others. The original plan of alternative B limits its service in the already urbanized area and some lines are planned as trunk bus routes. As a conclusion, Alternative A will be further studied to combine with road network alternatives in the next Chapter.

Table 10.3-1 Preliminary Evaluation of Mass-Transit Network

Alternative Network of Mass-Transit	Total Length (km)	Potential Demand	
		Passenger-km (million/day)	Passenger (1000/day)
A	109.6	90.2	823
B	122.5	98.6	805
C	88.4	51.6	584
D	106.2	77.2	727

Note: Passenger = Passenger km / Total Length

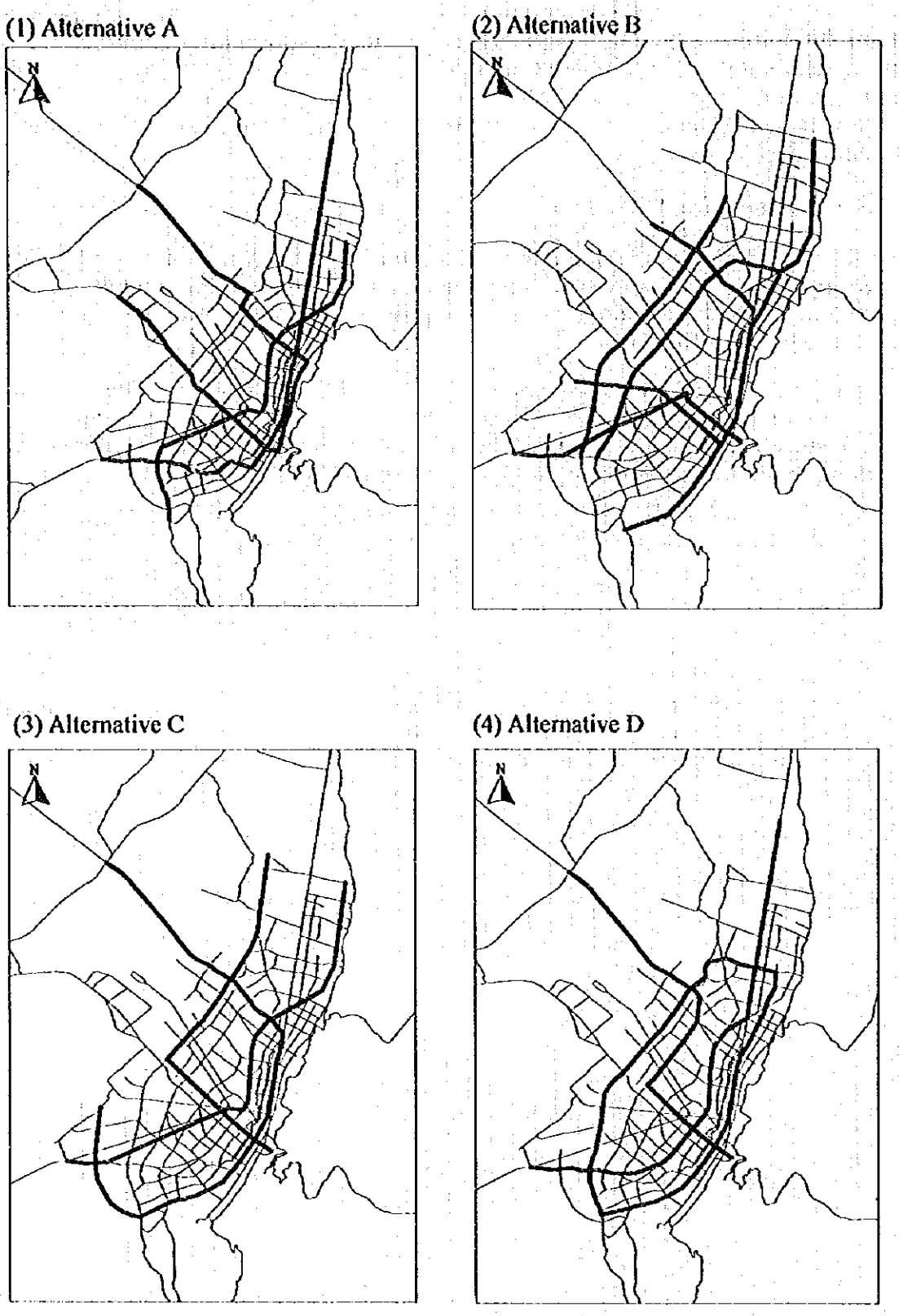


Figure 10.3-4 Alternative Network Of Mass-Transit

10.4 Formulation of Alternative Transport Network Plan

The transport network alternative plan study is done to identify the transport mode to be examined in the long term (2020), in the Study of Urban Transport of Santa Fe de Bogota.

In accordance with the selected transport network alternative plans, the sector plans such as the road plan, the public transport plan, and the traffic management plan will be examined. In the sector plan study, a necessity of each transport mode, traffic demand, and more detailed engineering aspects are examined. Therefore, locations of routes of transport modes are identified.

10.4.1 Basic Concept for Urban Transport Master Plan

(1) Urban Transport Issues in Bogota

The transport problems and issues in Bogota are identified based on the existing traffic conditions and the forecasted future travel demand. The main points of the problems and issues are the followings;

a) Future traffic flows concentrate in the Central Business District (CBD) which is covered by Avenida Quito and Avenida 7a based on the future traffic desire lines. This is a similar pattern as of present. Traffic flows from northern areas reach approximately 3 times the present flows. Therefore, in these areas, traffic congestion will be heavier in the year 2020.
b) According to the analysis of the Person Trip survey data, trip characteristics between motorized and non-motorized households are different per travel mode, i.e., motorized household members mainly use the passenger car, while non-motorized households use public bus transport. Approximately 75 % of total trips use bus transport in 1995, in contrast to about 60 % in 2020. The majority of transport modes in the future is still the public transport. Therefore, it is indispensable to plan for both the road network and the public transport network.
c) Presently, the level of bus transport service is low. It is indispensable to improve the service level of public transport.
d) In 2020, traffic volume in the Study Area will reach 1.55 times the present volume, while the population in Bogota will be 1.45 times the present. At present, there is the future road network plan in Bogota, formulated by DAPD. In the previous section, the future road network plan was roughly examined in terms of traffic volume/capacity ratio by traffic assignment. It is obvious that road network development plans only will not be sufficient for the increased future traffic volume, i.e., demand and capacity are in imbalance. Since it is difficult to make the future traffic demand coincide with the road facility length or volume, it is indispensable to execute the traffic management plan, a traffic demand control and a traffic flow control, in the future.

(2) Basic Concept for the Formulation of the Master Plan

Considering future transport conditions and the present transport problems and issues in Bogota, the following basic concept for preparing the Urban Transport Master Plan is shown.

a) The traffic congestion will concentrate in the existing CBD in 2020, and this area is required to improve the existing road network, and transport network and systems. However, it is very difficult to widen existing roads, due to insufficient

room for widening these roads. In this area, grade separated transport network systems, improvement plans of small size roads and traffic management plans should be prepared, considering the above mentioned conditions.

b) An Urban Transport Master Plan is examined based on the combination plan among three (3) different types of transport systems, which are road network, busway network and railway network development plans.
c) Considering the future transport demand in Bogota and its surrounding areas, a powerful public transport plan should be formulated.

10.4.2 Transport Network Plans

In the previous sections, two (2) transport network development plans were studied for the preparation of the Urban Transport Master Plan. The Transport Network alternatives were prepared as combination plans among the public transport development plans and the road network development plans.

(1) Road Network Plan

As mentioned in Chapter 10.1, the following three (3) road network plans are employed, taking into account future land use, traffic characteristics, the existing road network, and future travel demand.

a) Road Network Development Plan (Base Network)
b) Road Network Development Plan (R-1)
c) Urban Expressway Network Development Plan (R-2)

(2) Public Transport Network Plan

In Chapter 12, two (2) public transport alternative network plans were employed to strengthen the public transport plan, taking into account the functions and characteristics of the public transport systems and future travel demand.

1) Busway Development Plan

a) Busway Route-1 (BS-1)
b) Busway Route-2 (BS-2)
c) Busway Route-3 (BS-3)

2) Railway Development Plan

a) Railway Route-1 (RL-1)
b) Railway Route-2 (RL-2)
c) Railway Route-3 (RL-3)

10.4.3 Formulation of Transport Network Alternatives for the Preparation of Master Plan in 2020

Transport network alternatives are formulated in consideration of the following;

a) To increase the capacity of transport facilities in accordance with future traffic flow and the volumes of private and public transport passengers, and
b) To introduce public transport with a high service level as well as traffic demand control, to divert traffic from the passenger car to public transport.

The alternatives are composed of the followings; three (3) road network plans (Base Network, R-1 and R-2) oriented to the road network, two (2) public transport network plans (Busway and Railway) are oriented to public transport,) for mitigation of traffic congestion in certain areas .

The number of alternative cases totals 17, in combination with the above-mentioned

components, as shown in Table 10.4-1 and Table 10.4-2. Figure 10.4-1 to Figure 10.4-5 also show each alternative network plan composed of at grade roads, urban expressways, segregated busways, and the railway system.

Alternative A is the future road network plan in Bogota formulated by DAPD. In Alternative B, several major roads are added in Alternative A's road network, based on the analysis of traffic assignment on the road network on Alternative A. Alternative C has the urban expressway system, composed of ring roads around the central business areas and roads radiating in the direction of major traffic flows, adding to Alternative B's network.

Alternatives P, D, and E have three segregated busway routes on Alternative A, B, and C's networks, respectively. These segregated busways are planned on the at grade roads with 4 lanes in both directions. On these roads with busway, the right of way for private vehicles is reduced to improve the bus service level.

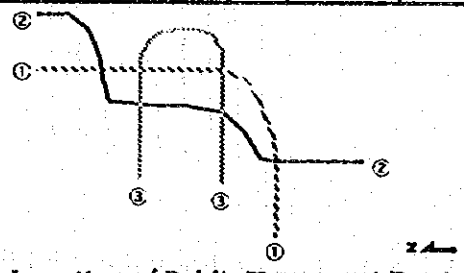
As for Alternatives Q, F, and G, three rapid railway routes are planned on Alternative A, B, and C's networks, respectively. The railway routes pass through the same route as that of the busway, with elevated structure over at-grade roads. These alternatives are quite different from the busway system. The railway system does not disturb the lanes for private vehicles.

Alternatives H to O are combination plans among three routes with busway and railway routes. That is, a combination with one or two busways, and two or one railways.

The do-nothing case which is without any future plan is also set as a ground case, to evaluate the alternatives. Thus, alternatives are evaluated as differences between a certain alternative and the do-nothing case in terms of VOC and Time Saving.

Table 10.4-1 Formulation of the Network Alternative Plan

Public Transport Development Plans / Road Network Development Plans	Existing Public Transport	Busway Network Plan, Busway (1)+(2)+(3)	Railway Network Plan, Railway (1)+(2)+(3)	Combination Plan (1), Busway (2) Railway (1)+(3)	Combination Plan (2), Busway (1)+(2) Railway (3)	Combination Plan (3), Busway (1)+(3) Railway (2)	Combination Plan (4), Busway (2)+(3) Railway (1)
Existing Road Network	Do-Nothing						
Road Network Plan (1) (DAPD Net)	Plan-A	Plan-P	Plan-Q				
Road Network Plan (2) (DAPD Net + Additional Roads)	Plan-B	Plan-D	Plan-F	Plan-H	Plan-J	Plan-L	Plan-N
Road Network Plan (3) (1/2) + Expressway	Plan-C	Plan-E	Plan-G	Plan-I	Plan-K	Plan-M	Plan-O



Location of Public Transport Routes

Table 10.4-2 Detailed Combination Plans

(Unit:Km)

Planning	Do-Nothing	Plan A	Plan B	Plan C	Plan D	Plan E	Plan F	Plan G	Plan H
V-0 Road	44	81	81	81	81	81	81	81	81
V-1 Road	119	163	163	163	163	163	163	163	163
V-2 Road	161	254	283	283	283	283	283	283	283
V-3 Road	226	377	406	406	406	406	406	406	406
Total Road Length	550	875	933	933	933	933	933	933	933
Urban Expressway	0	0	0	92	0	92	0	51	0
Busway	Av. Caracas	0	0	0	110	110	0	0	30
Railway	0	0	0	0	0	0	110	110	80

Planning	Plan I	Plan J	Plan K	Plan L	Plan M	Plan N	Plan O	Plan P	Plan Q
V-0 Road	81	81	81	81	81	81	81	81	81
V-1 Road	163	163	163	163	163	163	163	163	163
V-2 Road	283	283	283	283	283	283	283	283	283
V-3 Road	406	406	406	406	406	406	406	406	406
Total Road Length	933	933	933	933	933	933	933	933	933
Urban Expressway	67	0	86	0	68	0	67	0	0
Busway	30	71	71	80	80	69	69	110	0
Railway	80	39	39	30	30	41	41	0	110

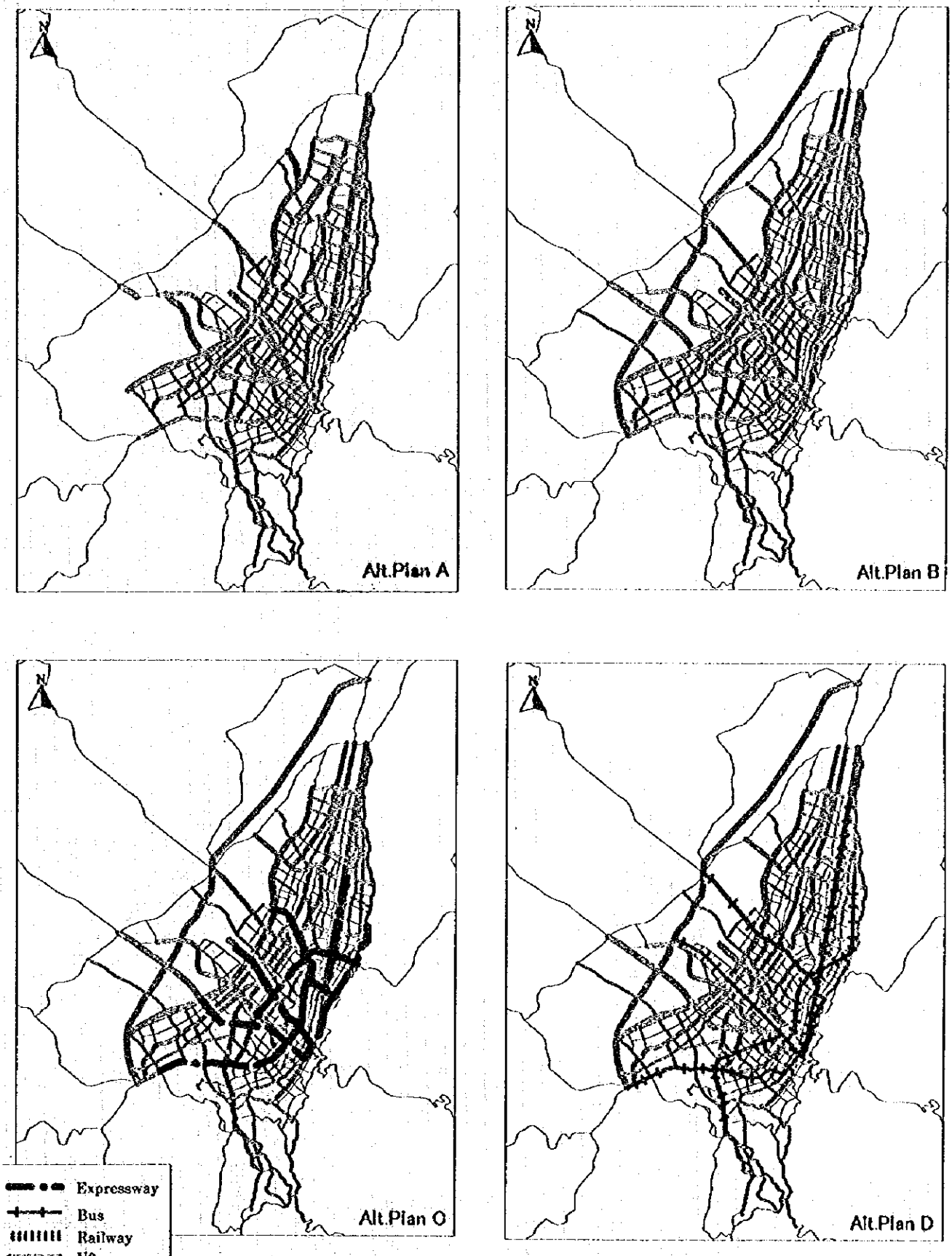


Figure 10.4-1 Transport Network Alternative Plans A, B, C, and D

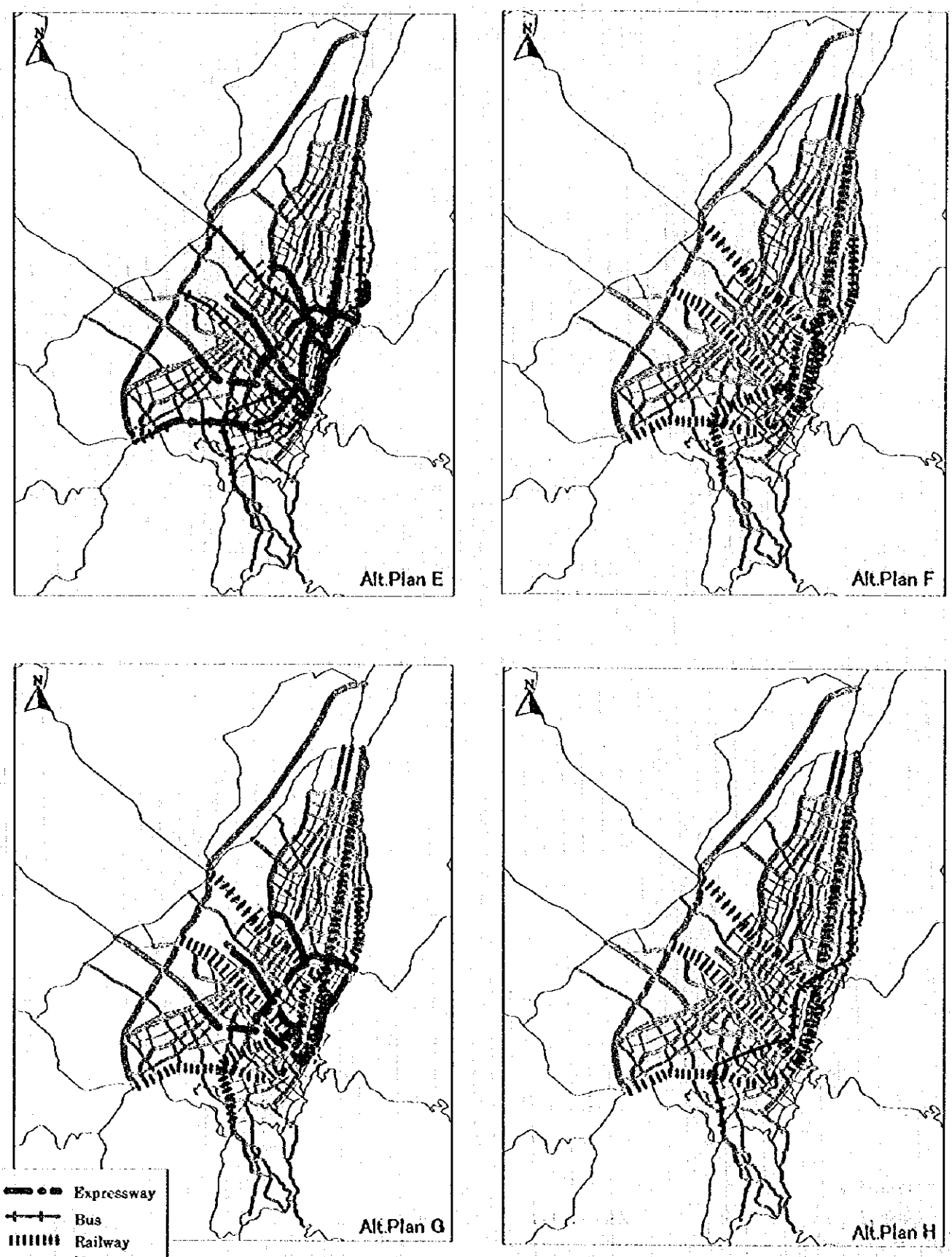


Figure 10.4-2 Transport Network Alternative Plans E, F, G, and H

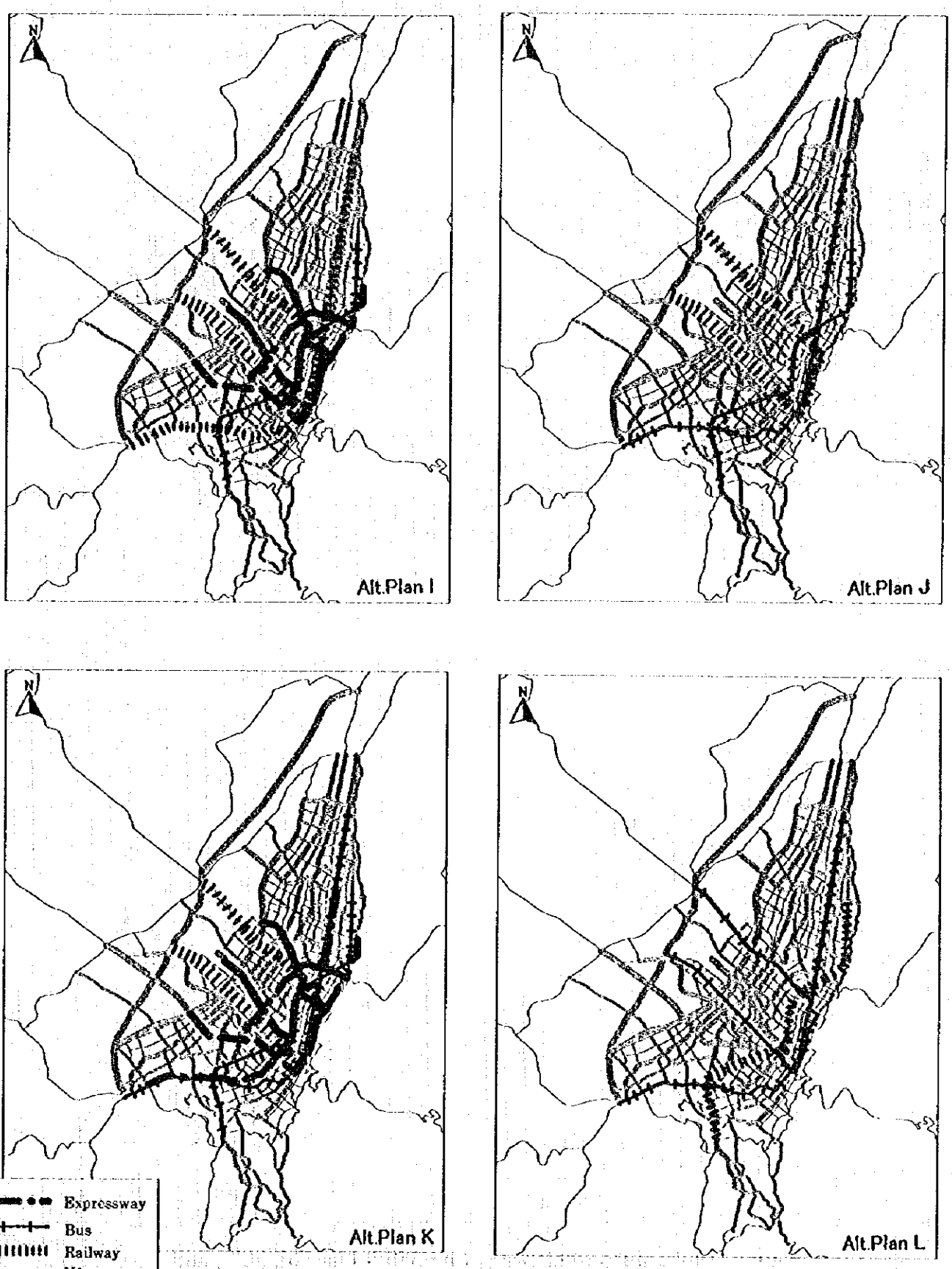


Figure 10.4-3 Transport Network Alternative Plans I, J, K, and L

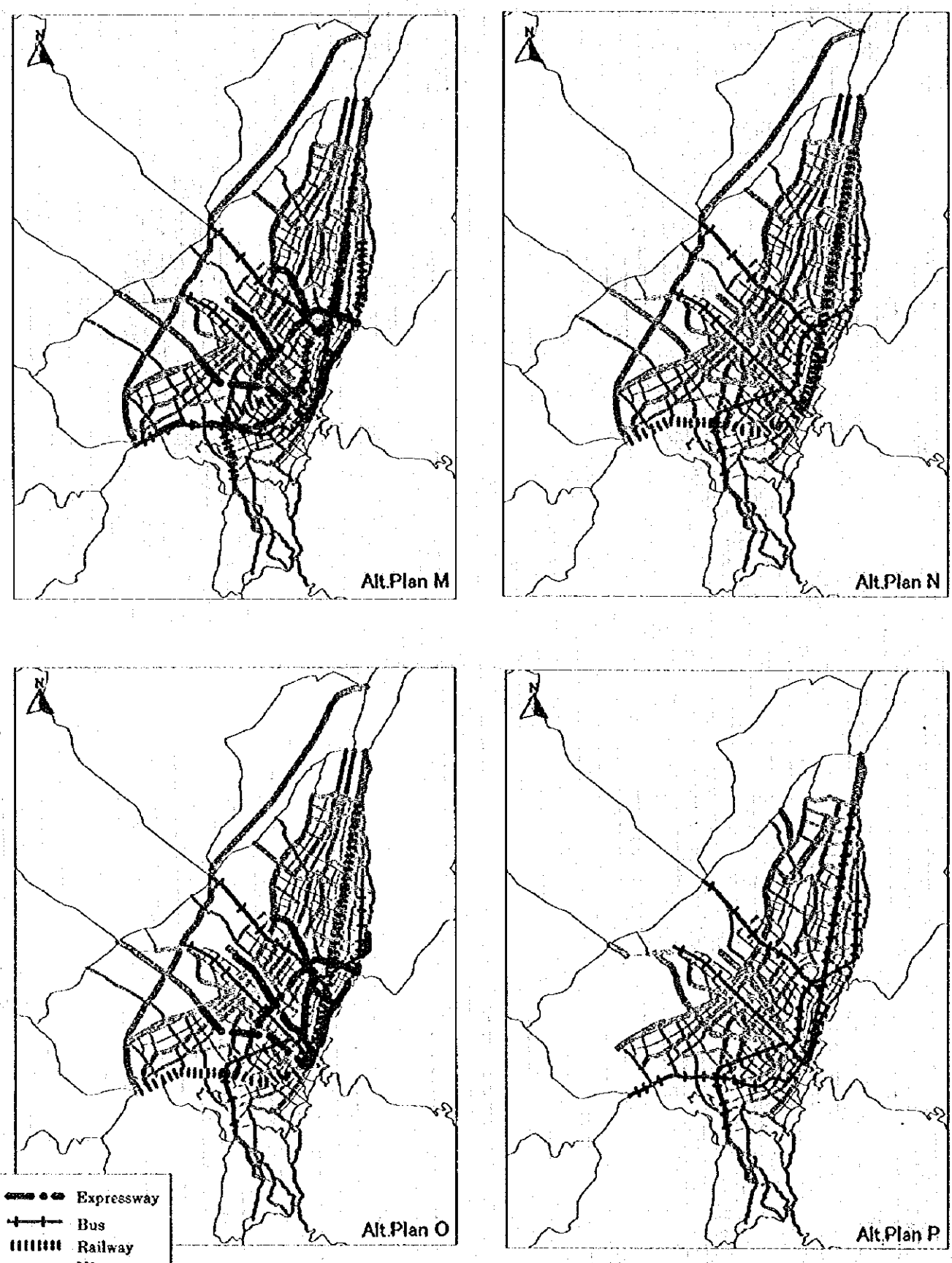
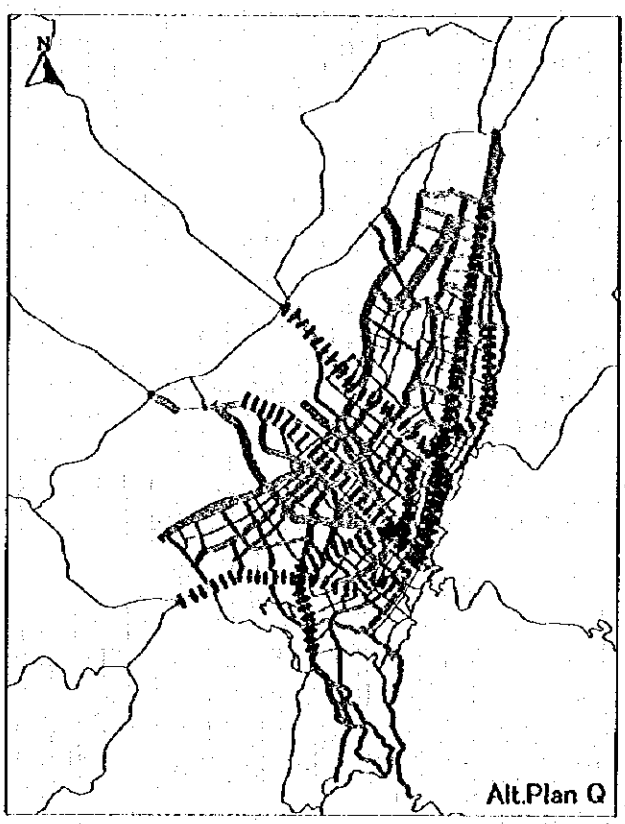


Figure 10.4-4 Transport Network Alternative Plans M, N, O, and P



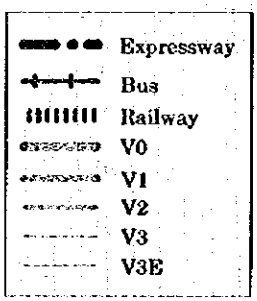


Figure 10.4-5 Transport Network Alternative Plan Q

10.5 Evaluation of the Transport Network Plan

10.5.1 Traffic Analysis of Seventeen (17) Alternative Plans

The evaluation of alternatives is judged by the traffic assignment method by which the year 2020's OD table is assigned to each alternative transport network. The following traffic indices are analyzed by the traffic assignment.

a) Total person- km (1,000 person-km)
b) Total person-hrs. (1,000 person-hours)
c) Total pcu-km (1,000 pcu-km)
d) Total pcu-hrs. (1,000 pcu-hours)
e) Average travel speed (km/h)
f) Average traffic congestion volume/capacity ratio(v/c ratio) and 4 ranked V/C ratio (less than 0.8, between 0.8 and 1.0, between 1.0 and 1.5, and 1.5 or more)

The following issues emerge;

1) Figure 10.5-1 shows travel speed and V/C ratio on the roads and busway/railway per Alternative Plan. As can be seen, Alternative Plan-A is the lowest in travel speed among the seventeen (17) Alternative Plans, and besides travel speed, the V/C ratio is the highest of all. The accumulated road length with 1.5 or more of the V/C ratio totals 72 km, equivalent to 8 % of the total road length in the Study Area. Those heavily congested roads still remain in the CBD.

2) Alternative Plan-B shows some change for the improvement in terms of travel speed and the V/C ratio. The travel speed rises to 14 km/h, in contrast to 11.6 km/h for Alternative Plan-A. Road length with the V/C ratio of 1.5 or more is reduced to 52 km. Those heavily congested roads still remain in the CBD.

3) Alternative Plan-C with Urban Expressway brings about a better, acceptable service level with travel speed at 17.4 km/h. The ratio of increase in travel speed rises about 50% compared to Alternative Plan-A. By planning the Urban Expressway around the CBD and on heavy traffic corridors, the traffic congestion in the CBD is fairly alleviated, and road length with V/C ratio of 1.5 or more reduces to 38 km. It is obvious that Alternative Plan-C is one of the best alternative from the viewpoint of traffic aspects.

4) Introducing the segregated Busway reduces the service level of Alternative Plan-D and Alternative Plan-E compared to Alternative Plans -B and C. This is because the road capacity for private transport is decreased to introduce the segregated Busway. Comparing Alternative Plan-E with C, the ratio of reduction of travel speed is about 12 % of Alternative Plan-C. The bus passengers on the Busway, however, enjoy good service with travel speed of 20 km/h, while it is 15 km/h for cars as shown in Figure 10.5-2. Total person-km of the bus passengers is about 2 times that of car passengers(see Figure 10.5-3). By introducing the segregated Busway, bus passengers, who predominate as the transport mode, enjoy a good service, as long as car user submit to restraint.

5) Alternative Plan-G with the Urban Expressway serves the highest travel speed (19 km/h) among the Alternative Plans. Public transport passengers by railway receive the best service because of travel speed of the railway. The figure is at 28 km/h. If the Expressway is not planned(Alternative Plan-F), effectiveness is reduced to about 10 %.

6) Among Alternatives H to O, which are combination plans among three routes between busway and railway routes, the service level on each alternative is in the middle between Alternative Plan-D and G.

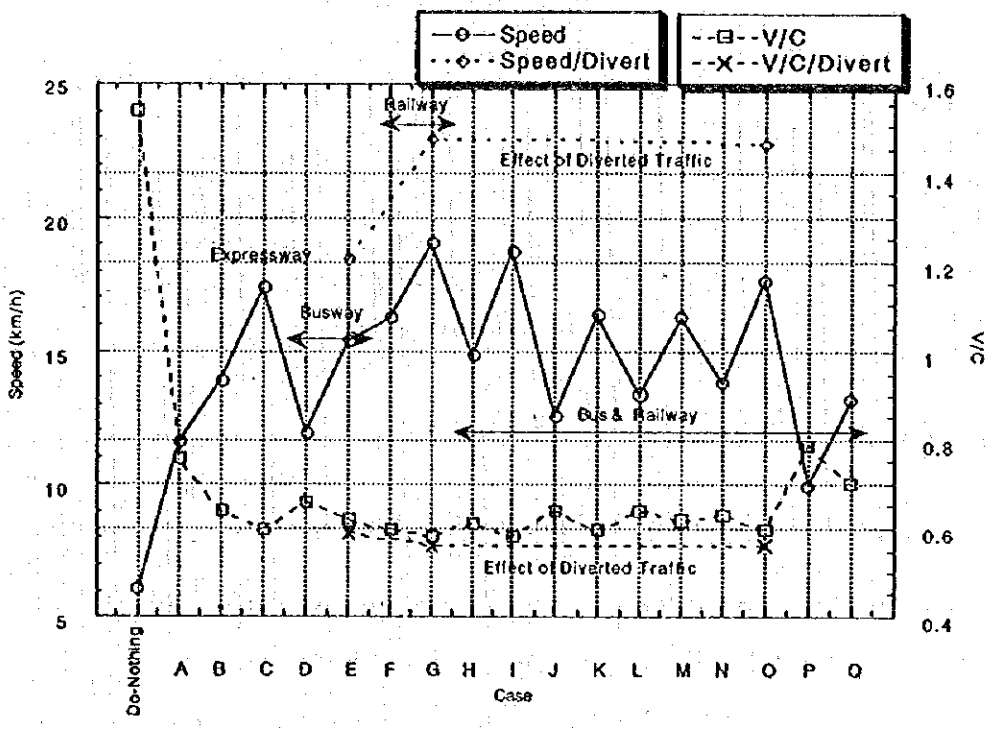


Figure 10.5-1 Travel Speed and V/C Ratio on Alternative Plans

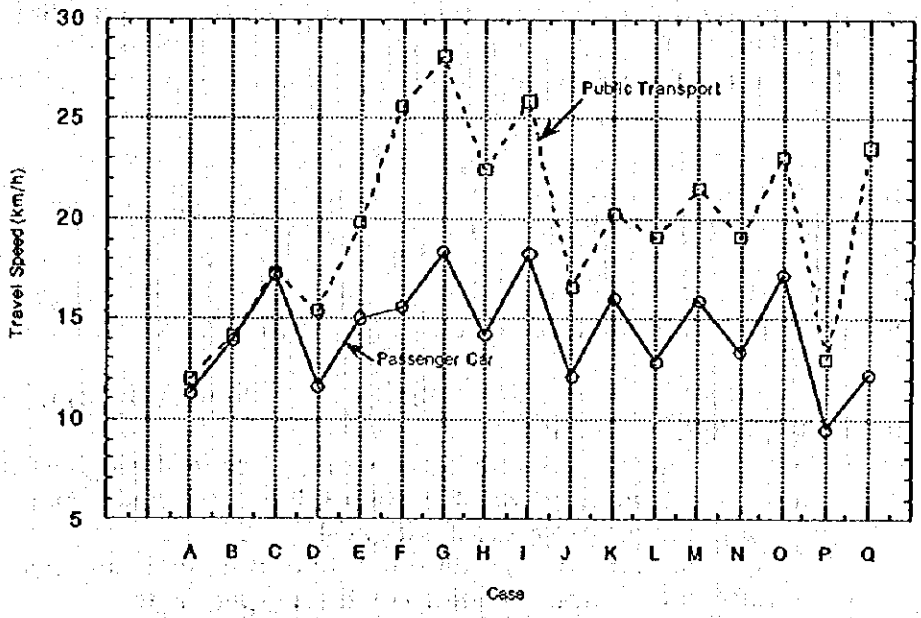


Figure 10.5-2 Travel Speed for Car and Bus Passenger

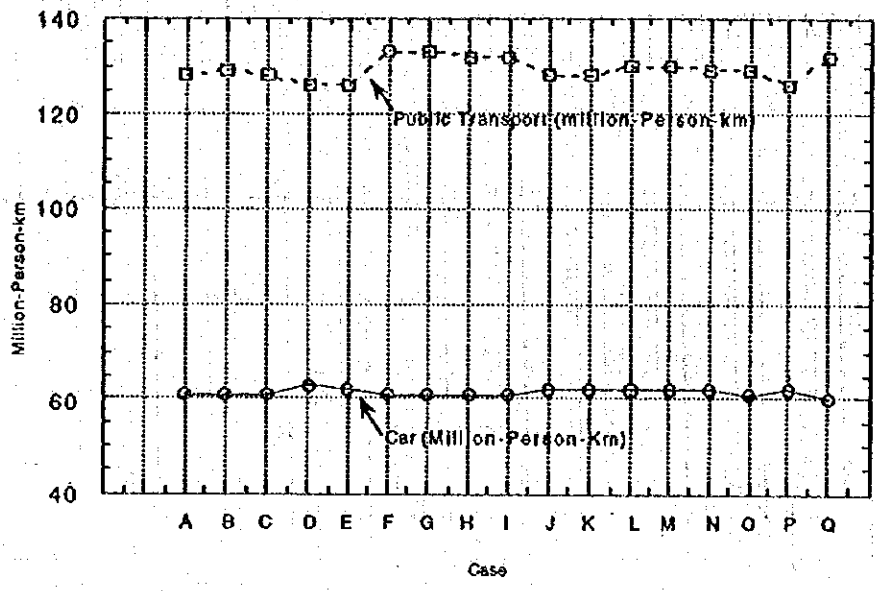


Figure 10.5-3 Total Car and Bus Passengers Person-km by Alternatives

10.5.2 Selection and Evaluation of Transport Network Alternative Plan

(1) First Stage Selection of Alternative Plans

The characteristics of the 17 alternative plans are disclosed in terms of the average travel speed, and average traffic congestion degree (V/C Ratio) on the future road and public transport networks. In this section, the better alternative plans, as the primary selection, are chosen among the 17 alternative plans.

In the primary selection, six (6) alternative plans are chosen from the viewpoint of service level and project cost, which is the average travel speed and degree of congestion (V/C ratio) and construction cost. Table 10.5-1 shows the rough estimate of construction cost and benefit for time saving and VOC for each alternative plan. Alternative Plans-A, B, C, E, O and G were selected as a consequence of the following discussions.

a) Average travel speed of Alternative Plan-A is forecasted at 11.6 km/h, which is very low. Alternative Plan-A, however, is approved by the cabinet of municipality of Santa Fe de Bogota. This Alternative Plan-A is selected as a Basic Alternative Plan.
b) Alternative Plan-B is the least cost project among sixteen (16) Alternative Plans excluding Alternative Plan-A which is not sufficient to preserve traffic service levels.
c) Alternative-E, as the representative of the Busway Project, presents better traffic service level than Alternative -D.
d) Alternative-G which includes a full railway network, presents the highest traffic service level among the 17 alternatives. This alternative is selected as one of the best alternative plans, but the project cost is highest.
e) Alternative Plan-O is selected as the representative of a combination project among three (3) different transport modes. The travel speed is the highest (17.8 km/h) among combination plans.

Table 10.5-1 Comparison of Cost and Benefit for Alternative Plans

Item		Unit	Do-Nothing	Alt-A	Alt-B	Alt-C	Alt-D	Alt-E	Alt-F	Alt-G	Alt-H	Alt-I
1) Car	Person-Km	000ps.km	68,648	60,674	61,109	60,553	62,553	62,066	60,589	60,876	61,276	60,956
	Person-Hrs	000ps.hrs	11,497	5,371	4,396	3,507	5,393	4,137	3,888	3,327	4,315	3,347
		Ratio to Total										
2) Public	Person-Km	000ps.km	139,855	128,184	128,926	127,930	126,498	126,498	132,657	132,657	131,826	131,826
	Person-Hrs	000ps.hrs	22,677	10,696	9,133	7,389	8,226	6,391	5,177	4,715	5,862	5,094
3) Taxi	Person-Km	000ps.km	26,256	23,508	23,640	23,400	24,279	24,067	23,432	23,555	23,696	23,594
	Person-Hrs	000ps.hrs	4,335	2,163	1,847	1,435	2,256	1,717	1,628	1,373	1,794	1,393
4) Truck	Person-Km	000ps.km	7,586	6,945	7,079	7,058	7,226	7,164	7,028	7,041	7,064	7,069
	Person-Hrs	000ps.hrs	1,159	435	385	324	474	378	336	298	208	310
5) Construction Cost	Total	million US$		3,557	4,822	7,343	5,122	7,512	16,920	18,047	14,127	15,967
	/year	million US$		506	617	940	656	962	2,166	2,310	1,808	2,044
6) Benefit for Do-Nothing												
Car	/year	million US$		2,411	2,757	3,094	2,362	2,831	2,954	3,152	2,783	3,143
Public	/year	million US$		1,116	1,257	1,418	1,344	1,512	1,611	1,653	1,550	1,620
Taxi	/year	million US$		835	949	1,103	790	990	1,032	1,123	967	1,115
Truck	/year	million US$		107	108	110	85	98	110	113	114	111
Total	/year	million US$		4,468	5,065	5,725	4,581	5,430	5,707	6,041	5,415	5,989
B/C Ratio	Ratio			8.82	8.21	6.09	6.99	5.65	2.64	2.62	2.99	2.93

Item		Unit	Alt-J	Alt-K	Alt-L	Alt-M	Alt-N	Alt-O	Alt-P	Alt-Q	Remarks	
1) Car	Person-Km	000ps.km	62,114	61,511	61,669	61,973	61,693	61,195	62,283	60,210		
	Person-Hrs	000ps.hrs	5,105	3,838	4,765	3,895	4,611	3,559	6,528	4,899		
		Ratio to Total										
2) Public	Person-Km	000ps.km	128,357	128,357	129,889	129,889	129,246	129,246	125,983	132,126		
	Person-Hrs	000ps.hrs	7,753	6,326	6,808	6,021	6,777	5,583	9,682	5,608		
3) Taxi	Person-Km	000ps.km	24,074	23,810	23,945	24,068	23,908	23,669	24,202	23,401		
	Person-Hrs	000ps.hrs	2,121	1,604	2,005	1,650	1,942	1,455	2,593	1,958		
4) Truck	Person-Km	000ps.km	7,208	7,118	7,133	7,145	7,102	7,069	7,080	6,926		
	Person-Hrs	000ps.hrs	456	360	417	360	394	322	563	402		
5) Construction Cost	Total	million US$	9,727	11,567	7,915	9,755	9,522	11,372	4,257	15,055		
	/year	million US$	1,245	1,481	1,013	1,249	1,219	1,456	545	2,055		
6) Benefit for Do-Nothing											US$/km	US$/hr
Car	/year	million US$	2,476	2,952	2,610	2,921	2,655	3,061	1,953	2,593	0.0600962	1.0
Public	/year	million US$	1,384	1,514	1,467	1,539	1,471	1,580	1,212	1,572	0.0052632	0.3
Taxi	/year	million US$	842	1,035	867	1,014	910	1,081	658	912	0.0429492	1.0
Truck	/year	million US$	88	108	96	101	100	109	86	111	0.1730304	0.3
Total	/year	million US$	4,790	5,604	5,060	5,575	5,148	5,831	3,920	5,189		
7) B/C Ratio to Do-Nothing	Ratio		3.85	3.78	4.99	4.46	4.22	4.01	7.19	2.52		

(2) Selection and Evaluation of Transport Network Alternative Plan

In this section, the best alternative plan is chosen from the primarily selected 6 alternatives as the preliminary transport network for examination of sector plan. Prior to the selection of the best alternative plan, three (3) additional Alternative Plans, considering the traffic diverted from the private mode to the public mode, are prepared to take into account the improvement of the service level. Alternative Plan-E', G' and O', which have the same transport network configuration as those of Alternative Plans-E, G, and O, respectively, are added as the alternatives with intermodal diversion.

In the 17 alternative plans, the future travel demand is forecasted by two different modes; private and public transport modes. In this method, no diversion between the private and public transport modes is taken into account. As for the additional 3 alternatives with the prime mark, the diversion of traffic from the private to the public mode is considered under the condition that travel time difference between the private and the public of a certain OD pair is 30 minutes or more.

Table 10.5-2 shows traffic volume diverted from the private mode to the public. As can be seen, the diverted traffic volume ratios from car to bus in Alternative E, G, and O are 4 - 7 % of all car traffic in terms of PCU-km. The ratio of bus increases by 2 - 3 % of the total bus traffic. The total traffic of cars and buses is reduced to 94 -96 % of the

total. The travel speed with demand control is shown on the same column of Alternative E, G, and O in Figure 10.5-4. The effect of the intermodal diversion is approximately a 20- 30% rise in travel speed, and a 5 -6 % fall in the V/C ratio, respectively.

Table 10.5-3 shows the service level, project cost and benefit to Alternative Plan-A for six (6) alternative plans composed of Alternative Plans A, B, C, E', G', and O', substituted for Alternative Plans E, G, O. Figure 10.5-4 shows the relation between service level (travel speed) and project cost in all alternative plans. Figure 10.5-5 and Figure 10.5-6 show the area covered by 30 minute and 1 hour trips from the central part of the city.

Alternative Plans K, M, and O are selected as the preliminary transport networks to be examined for the Comprehensive Urban Transport Master Plan for Bogota, though the other alternative plans are also expected to be technically and economically effective. The major reasons for selecting Alternative Plans-K, M, and O are as follows;

1) The travel speeds of Alternative Plans K, M, and O are comparatively high among alternative plans.

2) In Figure 10.5-4, the envelope line B -E -O -G levels off after Alternatives K, M, and O, which means the investment efficiency will fall down after O, as the marginal cost for raising the average speed rises sharply.

3) The area within a one hour travel time on Alternative Plan-O can cover almost all the metropolitan area of Bogota, as shown in Figure 10.5-5 and Figure 10.5-6 .

The network of Alternative Plan-O is shown in Figure 10.5-7, and forecasted traffic volume on major roads on Alternative Plan -O by the traffic assignment is shown in Figure 10.5-8 for representative among there (3) Alternative Plans (Alt. K, M. and O)

The same transport mode is maintained in the three Alternative Plans; Alternative Plans K, M, and O. The transport network or mode in the three plans consists of the road networks, urban expressway networks, busway networks, and one railway route.

In the sector plans, these transport networks and one railway route will be verified as to technical feasibility for the Comprehensive Urban Transport Master Plan for Bogota.

Table 10.5-2 Traffic Volume Diverted from Private to Public

	Case E			Case G			Case O		
	Before	After	After/Before	Before	After	After/Before	Before	After	After/Before
(1) Road+Bus Segrigated Net									
Total PCU-KM	67,559,934	64,228,222	0.951	66,644,634	64,165,902	0.963	66,786,276	62,496,246	0.936
Total PCU-Hours	4,389,376	3,480,377	0.793	3,499,441	2,794,835	0.799	3,782,462	2,750,478	0.727
Total Capacity-KM	109,187,522	109,187,522	1.000	115,204,278	115,204,278	1.000	111,288,490	111,288,489	1.000
Speed (km/h)	15.39	18.45	1.199	19.04	22.96	1.206	17.66	22.72	1.287
V/C Ratio	0.619	0.588	0.951	0.578	0.557	0.963	0.600	0.562	0.936
(2) Road Network									
Total PCU-KM	65,719,132	62,352,856	0.949	63,054,101	60,450,938	0.959	64,172,846	59,810,215	0.932
Total PCU-Hours	4,339,701	3,424,664	0.789	3,419,465	2,712,086	0.793	3,723,909	2,689,596	0.722
Total Capacity-KM	106,144,770	106,144,770	1.000	108,212,398	108,212,398	1.000	106,753,142	106,753,141	1.000
Speed (km/h)	15.14	18.21	1.202	18.44	22.29	1.209	17.23	22.24	1.290
V/C Ratio	0.619	0.587	0.949	0.583	0.559	0.959	0.601	0.560	0.932
(3) Bus/ Railway Network									
Total PCU-KM	1,840,802	1,875,366	1.019	3,590,533	3,714,964	1.035	2,613,430	2,686,030	1.028
Total PCU-Hours	49,676	55,712	1.122	79,976	82,749	1.035	58,553	60,882	1.040
Total Capacity-KM	3,042,752	3,042,752	1.000	6,991,880	6,991,880	1.000	4,535,348	4,535,348	1.000
Speed (km/h)	37.06	33.66	0.908	44.90	44.89	1.000	44.63	44.12	0.988
V/C Ratio	0.605	0.616	1.019	0.514	0.531	1.035	0.576	0.592	1.028
Persons/km/dual/	357,255	363,963	1.019	696,835	720,984	1.035	507,203	521,293	1.028
(1) Road+Bus Segrigated Net									
V/C Ratio Km by Rank									
1) 0 <= <0.8	726.7	747.1	1.028	759.2	792.3	1.044	748.5	781.1	1.044
2) 0.8<= <1.0	196.2	209.2	1.066	201	189.4	0.942	170.6	204.2	1.197
3) 1.0<= < 1.5	245.6	245.3	0.999	209.8	192.3	0.917	248.8	201.5	0.810
4) 1.5 <=	60.2	27.0	0.449	16.1	12.1	0.752	34.9	15.8	0.453
Total	1228.7	1228.6	1.000	1186.1	1186.1	1.000	1202.8	1202.6	1.000

Table 10.5-3 Comparison of Alternative Plans

Items		Unit	Alt-A	Alt-B	Alt-C	Alt-E'	Alt-G'	Alt-O'	Remarks	
1) Road+Bus Segrigated Net										
Total PCU-KM		000PCU.Km	66,228	66,708	66,134	64,228	64,166	62,496		
Total PCU-Hours		000PCU.Hrs	5,709	4,774	3,602	3,480	2,795	2,750		
Total Capacity-KM		000PCU.Km	87,382	104,398	110,996	109,188	115,204	111,288		
Speed (km/h)		km/hr	11.6	14.0	17.4	18.5	23.0	22.7		
V/C Ratio			0.758	0.639	0.596	0.588	0.557	0.562		
2) Person-Km										
Car	Person-Km	000ps.km	60,674	61,109	60,553	56,628	56,550	53,800		
	Person-Hrs	000ps.hrs	5,371	4,396	3,507	3,063	2,505	2,343		
		Ratio to Total				0.95	0.96	0.93		
Public	Person-Km	000ps.km	128,184	128,926	127,930	130,604	136,431	135,393		
	Person-Hrs	000ps.hrs	10,696	9,133	7,389	6,247	4,476	5,428		
Taxi	Person-Km	000ps.km	23,568	23,640	23,400	23,761	23,466	23,525		
	Person-Hrs	000ps.hrs	2,163	1,847	1,435	1,432	1,147	1,151		
Truck	Person-Km	000ps.km	6,945	7,079	7,058	7,127	7,049	7,039		
	Person-Hrs	000ps.hrs	435	385	324	324	261	267		
3) Construction Cost	Total	million US$	3,957	4,822	7,343	7,512	18,047	11,372		
	/year	million US$	506	617	940	962	2,310	1,456		
4) Benefit for Alternative-A									US$/km	US$/hr
Car	/year	million US$		346	683	931	1,136	1,256	0.0601	1.0
Public	/year	million US$		141	302	401	552	467	0.00526	0.3
Taxi	/year	million US$		114	269	264	373	370	0.04295	1.0
Truck	/year	million US$		-4	3	-1	9	9	0.17301	0.3
Total	/year	million US$		598	1,257	1,595	2,070	2,102		

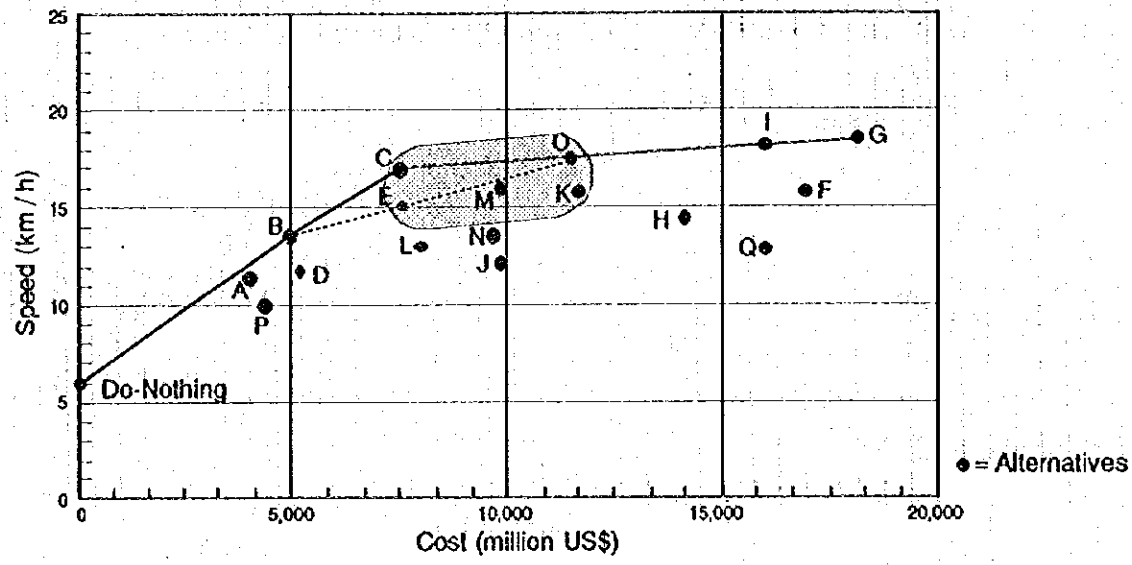


Figure 10.5-4 Relation Between Service Level and Project Cost

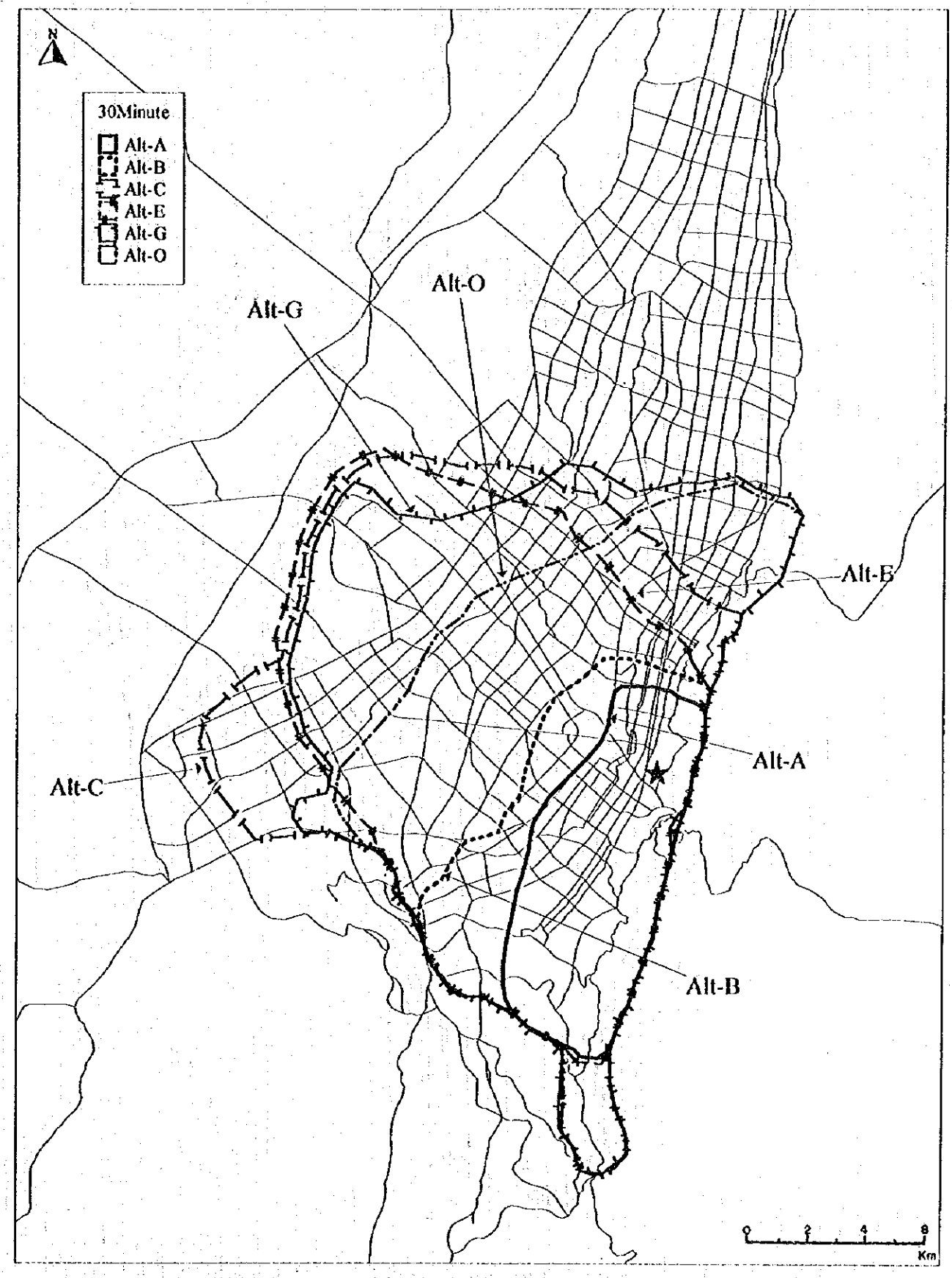


Figure 10.5-5 Covered Area for 30 minutes of Travel Time per Alternative Plan

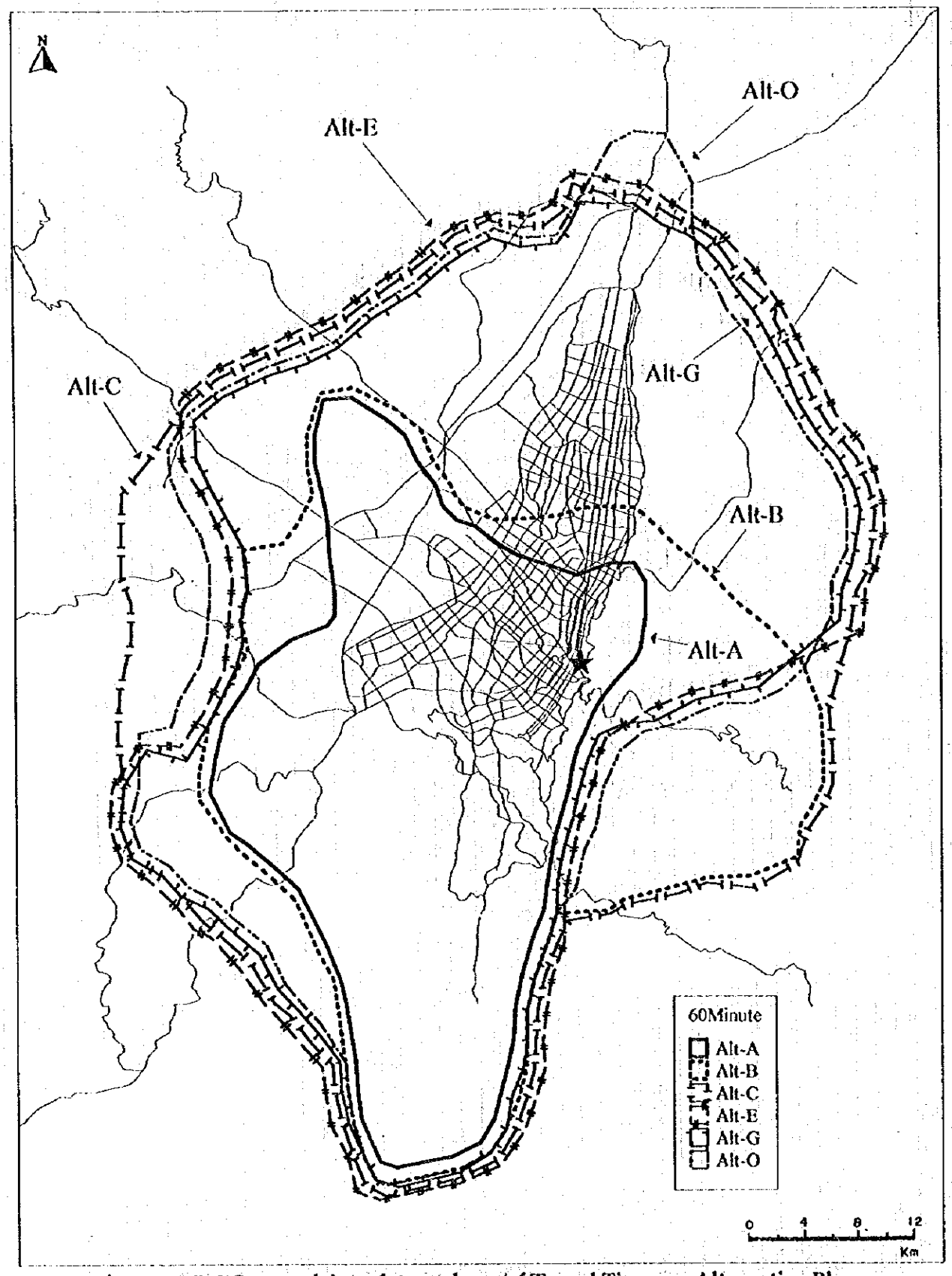


Figure 10.5-6 Covered Area for one hour of Travel Time per Alternative Plan

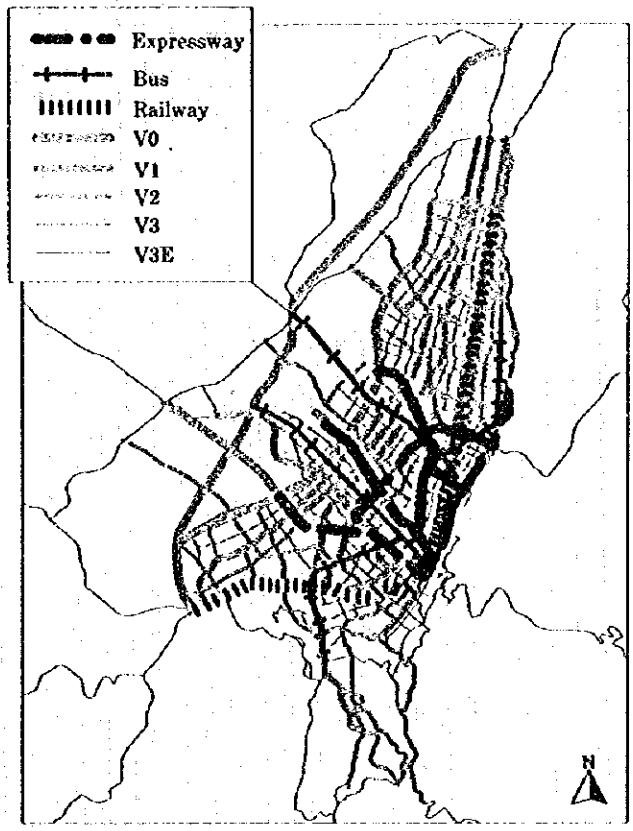


Figure 10.5-7 Transport Network in Alternative Plan-O

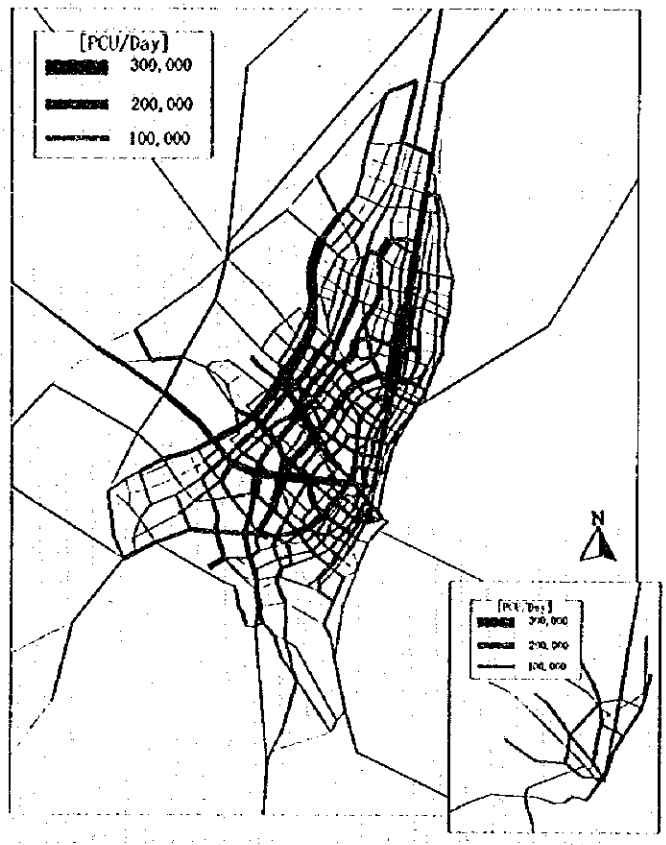


Figure 10.5-8 Traffic Assignment in Alternative Plan-O

CHAPTER 11
Road Sector Plan

11. ROAD SECTOR PLAN

As mentioned in Chapter 10, seventeen (17) Alternative Transport Network Plans were examined. The following transport networks are selected in preparation of the Comprehensive Urban Transport Master Plan.

1) Road Network Development Plan
2) Busway Network Development Plan
3) Railway Network Development Plan

In this chapter, based on the selected road network development plans, the road development plans were examined to verify the technical aspects of the selected road network plan, and to prepare the various road development plans for mitigation of traffic problems in Bogota. Bus and railway network development plans are examined in Chapter 12, "Public Transport Sector Plan".

11.1 Basic Consideration for Road Planning

11.1.1 Description of Road Network to be Studied

(1) Future Road Network Pattern

The existing trunk road network pattern in Bogota is formed as a ring and radial roads pattern, and the future road network pattern in 2020 is basically formed as five (5) ring and nine (9) radial roads, as described below, considering the existing road network pattern, urban development activities, and future traffic demand pattern.

1) Major Ring Roads in Bogota
   a) Avenida Quito (V-1) ----------As existing road network
   b) Calle 100 and Call 68 (V-1 and V-2) ----------As existing road network
   c) Avenida Boyaca (V-1)----------As existing road network
   d) Avenida Cali (V-1 and V-2) ----------As new road network
   e) Avenida Cundinamarca (V-1)----------As new road network

2) Major Radial Roads in Bogota
   a) Avenida 7a (V-2) ----------As existing road network
   b) Autopista Norte (V-0)----------As existing road network
   c) Avenida Low Murtra (Boyaca Extension)(V-1)---As new road network
   d) Avenida San Jose (V-1)----------As new road network
   e) Autopista Medellin (V-1)----------As existing road network
   f) Autopista El Dorado(V-0)----------As existing road network
   g) Avenida Centenario (V-1)----------As existing road network
   h) Autopista Americas (V-0) ----------As existing road network
   i) Autopista Sur (V-1) ----------As existing road network

(2) Road Length in 2020 by Road Class

The total road length of the future road network in 2020 of Bogota is planned at 1,015 km. The existing road length is about 550 km and the new road length is about 465 km. The total road lengths by road class such as V-0 to V-3 road class are shown in Table 11.1-1.

Table 11.1-1 Road Lengths in Future Road Network in 2020

Road Class	Existing Road	New Road	Urban Expressway	Total
V-0 (km)	43.5	47.2	-------	90.7
V-1 (km)	119.3	50.4	64.5	234.2
V-2 (km)	160.6	122.8	-------	283.4
V-3 (km)	226.4	179.8	-------	406.2
Total	549.8	400.2	64.5	1,014.5

11.1.2 Future Traffic Demand Characteristics in 2020

The future traffic demand in 2020 is assigned to the future transport network without an Urban Expressway network. From the traffic assignment, the following matters can be disclosed.

1) Traffic conditions in 2020 on the Avenida 7a, Calle 72, Avenida Quito will still be very heavy. The traffic volume in 2020 on the above mentioned roads will reach overcapacity. The traffic volume on these roads in 2020 are as follows;
   a) Avenida 7a ---------- over 90,000 to 120,000 pcu/day
   b) Calle 72---------- over 80,000 to 100,000 pcu/day
   c) Avenida Quito---------- over 120,000 to 190,000 pcu/day
   d) Avenida Caracas ---------- over 90,000 to 110,000 pcu/day

2) Traffic conditions on the major ring roads located at the outside of central area are also still very heavy, and the traffic volume on these roads will reach over capacity. The traffic volume in 2020 on these roads are as follows;
   a) Calle 100 ---------- over 160,000 pcu/day
   b) Calle 68---------- over 130,000 to 190,000 pcu/day
   c) Avenida Boyaca ---------- over 90,000 to 120,000 pcu/day

3) Traffic conditions on the major radial roads will be very congested. The estimated traffic volume on these roads will reach over capacity. The traffic volumes on these roads are as follows;
   a) Autopista Medellin ---------- over 80,000 to 100,000 pcu/day
   b) Autopista El Dorado ---------- over 190,000 to 200,000 pcu/day
   c) Autopista Sur---------- over 110,000 pcu/day
   d) Autopista Norte ---------- over 230,000 to 250,000 pcu/day

4) The estimated future traffic volume on the above mentioned major ring roads will reach overcapacity. The volume/capacity ratio (V/C) on these roads is forecasted at about 1.2 to 1.5.

5) The average travel speeds on these roads are also very slow. Especially, the average travel speed on Avenidas Caracas and 7a are forecasted at about less than 5 km/h.

11.1.3 Road Plan to be Examined

The road development plans are examined to mitigate the various urban transport problems, taking into account the existing road network configuration, transport characteristics, the future land use plan, and future traffic demand. Considering future traffic conditions, the four (4) road plans such as existing road improvement plans, grade separated intersection improvement plans, new road construction plans, and urban expressway construction plans, are all examined based on the road network of the selected Alternative Transport Network Plan mentioned in Chapter 10.

(1) Existing Road Improvement Plan

The major purposes of the preparation of the existing road improvement plans are to mitigate the traffic congestion of existing roads and to ensure smooth traffic flows and traffic safety. The most congested roads in Bogota are on the major radial roads, Avenida Caracas, and the roads located in the central area. The existing road improvement plan is directed to mitigate traffic congestion on these roads and areas.

(2) Grade-Separated Intersection Plan

Generally, the capacity of intersections is forecasted at about 60% to 70 % of capacity of general road segment, due to the time loss for signal phasing (green/red) in the intersection, as well as traffic conflict flows also occurring at intersections. Heavy traffic congestion was observed at major intersections in Bogota during traffic and field reconnaissance surveys.

The major purposes of constructing grade-separated intersections are to mitigate traffic congestion, and ensuring smooth and safe traffic flows, and to decrease traffic accidents at intersections.

(3) New Road (At-grade Road) Development Plan

The purposes of the new road construction plans are to increase the traffic service level and to mitigate traffic congestion in suburban areas in accordance with the increasing population.

The new road (At-grade road) development plans are designed based on the future road network prepared by DAPD in 1993 (Alternative Transport Network Plan-A described in Chapter 10) as the basic road network in the Study. Result of traffic analysis on the basic road network shows that the traffic service level (average running speed on all road network in Bogota is forecasted at about 11 km/h) of the basic road network is still weak. For improvement of low traffic service level on the basic road network, some additional roads are planned based on Alternative Plan-A (This is the Alternative Transport Network Plan-B described in Chapter 10).

Traffic service level (average running speed) on the road network with the additional roads is improved from 11 km/h to 14 km/h. However, the traffic of the central area is still very congested, also running speed on Avenida Caracas is forecasted at about 5 km/h.

(4) Urban Expressway Plan

The major purposes of the preparation of the urban expressway development plans are to mitigate the traffic congestion of the urban central area, and to improve the traffic conditions of major radial and ring roads in Bogota.

Urban expressway plans were examined in the light of mitigating traffic congestion in the central area. It is very difficult to construct over the winding of existing roads or construct new roads, because there is no room for widening roads or new road construction projects in the central area; and also, land acquisition prices are very high. Thus, the viaduct type is adopted for the urban expressway development plan in Bogota (Alternative Transport Network Plan-C described in Chapter 10). The average running speed on the road network with the urban expressway is improved from 11 km/h to 17 km/h.

11.2 Improvement Plan for Existing Roads

11.2.1 Concept of the Improvement Plan

The existing road improvement plans are carried out based on the following planning conditions.

a) To improve the road segments with heavy traffic congestion
b) To utilize the existing road facilities
c) To avoid large-scale land acquisition
d) To facilitate construction (comparatively small projects)
e) To harmonize the existing road network

11.2.2 Roads to be Improved

The problems of existing road facilities are identified as described in Chapter 4 following the field reconnaissance survey, the road inventory survey, the traffic count survey and its analysis. The heavy traffic congestion occurs on the existing Avenida Caracas, roads located in the center area, and four (4) radial trunk roads. The result of analysis of the travel speed survey by the JICA Study Team in 1995 indicates the average travel speed on these roads is observed at less than 10 km/h, during peak hours. In addition, many existing road improvement plans are prepared by IDU, and some projects are already authorized, and some projects are being implemented gradually. Prior to the preparation of existing road improvement plans, the JICA Study Team discussed with officers of IDU, the major roads to be improved are identified as follows;

a) Avenida Caracas
b) Roads within central area
c) Autopista Sur
d) Autopista Norte
e) Autopista Medellin
f) Avenida Centenario
g) Avenida 7a

11.2.3 Improvement Plans for Existing Road

The total of 25 existing road improvement plans are identified as shown in Table 11.2-1 and Figure 11.2-1, taking into account the traffic characteristics, existing road facilities conditions, and the planning concepts. The outline of the major improvement plans is as follows;

1) Almost all intersections which are located on Avenida Caracas are at-grade intersections. The existing traffic volume on Avenida Caracas is observed at 60,000 vehicles/day, and it is very difficult to cross the Avenida Caracas. To mitigate the traffic congestion on Avenida Caracas, Calles 34, 45, 53, and 63 should be improved as 4-lane dual carriageways, with grade separated intersections.

2) The traffic conditions of the existing four (4) radial roads such as Autopista Norte, Sur, Medellin, and Avenida Centenario are very heavy. The average travel speed on these roads during peak hours is observed at less than 10 km/h: as well, the road facilities conditions, such as pavement and drainage are very poor. Autopista Norte is classified as a V-0 road, and the other radial roads are classified as V-1 roads. The ROW of these roads have enough space for widening the roads. Considering the existing road space, it is comparatively easy to improve from a 6-lane to a 10-lane road. Considering the traffic characteristics, function of the road, and future

traffic demand, these roads should be improved as soon as possible.

3) The existing traffic volume on Carrera 11 is very heavy all day long. Carrera 11 has 3-lanes with one-way traffic; however, some segments on Carrera 11 are operated at 2-lanes, with a one-way road. The sections of 2-lane segment on Carrera 11 should be improved from 2-lanes to 3-lanes, without additional land acquisition.

4) The existing traffic volume on Avenida Mariscal is also very heavy. This road is operated as 2 to 3-lane road, and there are many buildings along the road. To mitigate the traffic congestion in the central area of Bogota, this road should be improved from 2 to 3-lane road to 4-lane road, without additional land acquisition.

5) The road facilities of existing roads located in the Fontibon area are very poor, especially the pavement and drainage facilities. To mitigate traffic congestion and ensure traffic safety, these roads located in the Fontibon area should be improved from 2-lane roads to 4-lane roads, with good drainage systems.

6) The side-walks on Carrera 15 and Avenida Jimenez are improved as the existing side-walk improvement plan, and the details of these plans are presented in Chapter 13.

Table 11.2-1 Summary of Road Improvement Plan

Name of Road	Length (km)	Road Class	Traffic Vol. 2020(1000pcu/d)	No. Lane Required	How Improved	Congestion Degree(V/C)
01)Car. 11	2.9	V-3	50 - 60	6	2---> 3-lane	1.80
02)Calle 63	0.5	V-3	70 - 90	8	3---> 4-lane	2.00
03)Calle 53	1.3	V-3	40 - 60	6	3---> 4-lane	1.25
04)Calle 45	2.0	V-3	80 - 90	8	3---> 4-lane	2.12
05)Calle 34	0.9	V-3	60 - 80	8	3---> 4-lane	1.75
06)Av. Mariscal	14.1	V-3E	50 - 60	6	2---> 3-lane	1.83
07)Av. Santander	2.5	V-3E	75 - 80	8	3---> 4-lane	2.00
08)Av. Conuneros	0.4	V-2	100	8	6---> 8-lane	1.04
09)Av. Indastrial	3.2	V-3E	20	4	2---> 4-lane	0.50
10)Av. Aranda	2.2	V-3E	20	4	2---> 4-lane	0.50
11)Av. Quiroga	1.7	V-3	50	6	2---> 4-lane	1.25
12)Av. Pedro	4.5	V-3E	60	6	2---> 4-lane	1.50
13)Av. San Juan	5.5	V-1	60	6	4---> 6-lane	0.67
14)Av. San Antonio	2.1	V-3	50	6	2---> 4-lane	1.25
15)Av. Casablanca	4.0	V-3	20	4	2---> 4-lane	0.50
16)Av. Fontibon	2.3	V-3	20	4	2---> 4-lane	0.50
17)Av. Versalles	1.5	V-3	20	4	2---> 4-lane	0.50
18)Av. T.D.M.	1.3	V-3	10	2	2---> 4-lane	0.25
19)Av. Luis	4.3	V-3	10	2	2---> 4-lane	0.25
20)Av.Tintal	3.5	V-3	10	2	2---> 4-lane	0.25
21)Av.Circunvalar	17.4	V-3E	60	6	2---> 4-lane	1.25
22)Auto. Llano	17.0	V-2	20	4	2---> 4-lane	0.41
23)Auto. Medellin	12.1	V-1	100	10	6--->10-lane	0.67
24)Av. Centyenario	10.9	V-1	137	12	6--->10-lane	1.14
25)Auto. Su	9.1	V-1	82	8	6--->10-lane	0.68
26)Av. Alberto(7a)	9.5	V-2	32	4	2---> 6-lane	0.44
27)Auto. Norte	9.2	V-0	0	10	6--->12-lane	0.69

11.2.4 Evaluation of the Improvement Plan

The evaluation of improvement plans is carried out based on the traffic effect comparison: "with plan" and "without plan". The 2001 traffic demand is assigned to

the With Plan and the Without Plan based on the existing road network. The results of the comparison (in year 2001 base) are summarized in Table 11.2-2. From this table, the following matters are pointed out.

a) With Plan, the average travel speed is improved from 25 to 26 km/h.
b) The pcu-km of With Plan is improved from 200 to 194 million-km.
c) The pcu-hour of With Plan is decreased from 7.5 to 8.0 million- hours.

Table 11.2-2 Traffic Comparison of the Improvement Plan

Items	With Plan (A)	Without Plan (B)	Effect
Ave. Speed (km/h)	26.6	21.9	+ 4.7
Total 1,000 PCU-km	31,870	31,938	+ 68
Total 1,000 PCU-h	1,196	1,455	+259

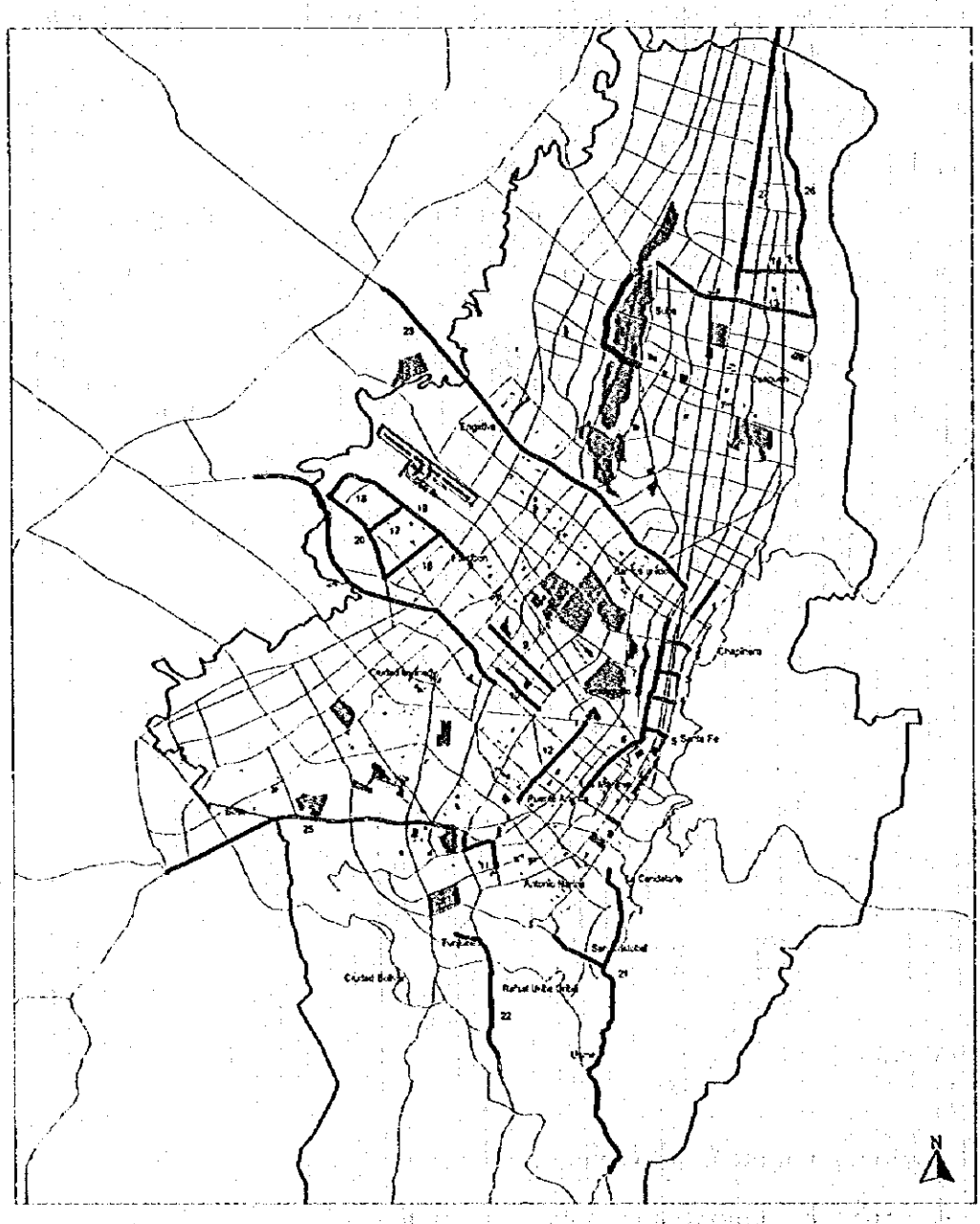


Figure 11.2-1 Location of the Existing Road Improvement Plan

11.3 Grade Separated Intersection Plan on the Existing Road Network

11.3.1 Concept of the Grade Separated Intersection Plan

Much traffic congestion have occured at the major intersections in Bogota, because actual traffic volume at intersections are overcapacitied; in addition, the traffic manners of drivers and pedestrian are very poor. The intersections are traffic bottlenecks in Bogota. To mitigate traffic congestion at major intersections, these should be improved from at-grade intersections to grade separated intersections, in accordance with the following concepts;

a) Major intersections which actual traffic volumes are overcapacitied
b) Intersections between a V-0 Road and a V-0 or V-1 Road.
c) Intersections between a V-1 Road and a V-1 or V-2 Road

11.3.2 Intersections to be Improved

The existing major intersections located on trunk roads were constructed as grade separated intersections. Total of seven (7) grade separated intersections are constructed on Autopista Norte, and 11 grade separated intersections are constructed on Autopista Sur and Avenida Quito, at present.

The intersections of saturated traffic flows observed from the traffic surveys were shown in Figure 4.2-3. These intersections were not constructed as grade-separated intersections. The intersections with saturated traffic flows are mainly located in the central area and on Avenida Caracas. It is required that these intersections be improved as grade-separated intersections, to ensure smooth and safe traffic flows and decrease traffic congestion.

1) Intersection on Avenida Circunvalar (V-3)

On Avenida Circunvalar, four (4) grade separated intersections are planned by IDU. These intersections are located in comparatively steep mountainous areas, and present traffic volume on this road is not so heavy. However, traffic volume in the future will increase rapidly. In addition, when Avenida 7a is congested, the Avenida Circunvalar will be used as a diversion route of Avenida 7a. Considering these traffic conditions in the future, the existing signalized four (4) intersections on Avenida Circunvalar will be improved as grade separated intersections.

2) Intersections on Autopista Medellin (V-1)

A total of four (4) grade separated intersections were constructed on Autopista Medellin. At present, the bus trunk road system development plan is being planned by IDU on this road. In accordance with the increase in traffic demand, this road should be included in the bus express system in the future. Taking into account the bus trunk road plan and the bus express plan, the major intersections on the Autopista Medellin should be improved as grade separated intersection at the same time of the construction of the bus trunk road system.

3) Intersections on Avenida Caracas (V-2)

As mentioned in Chapter 11.2, it is required that four (4) grade-separated intersections be constructed at the existing signalized intersections between Avenida Caracas and Calles 34, 45, 53, and 63. However, improvement of these intersections require