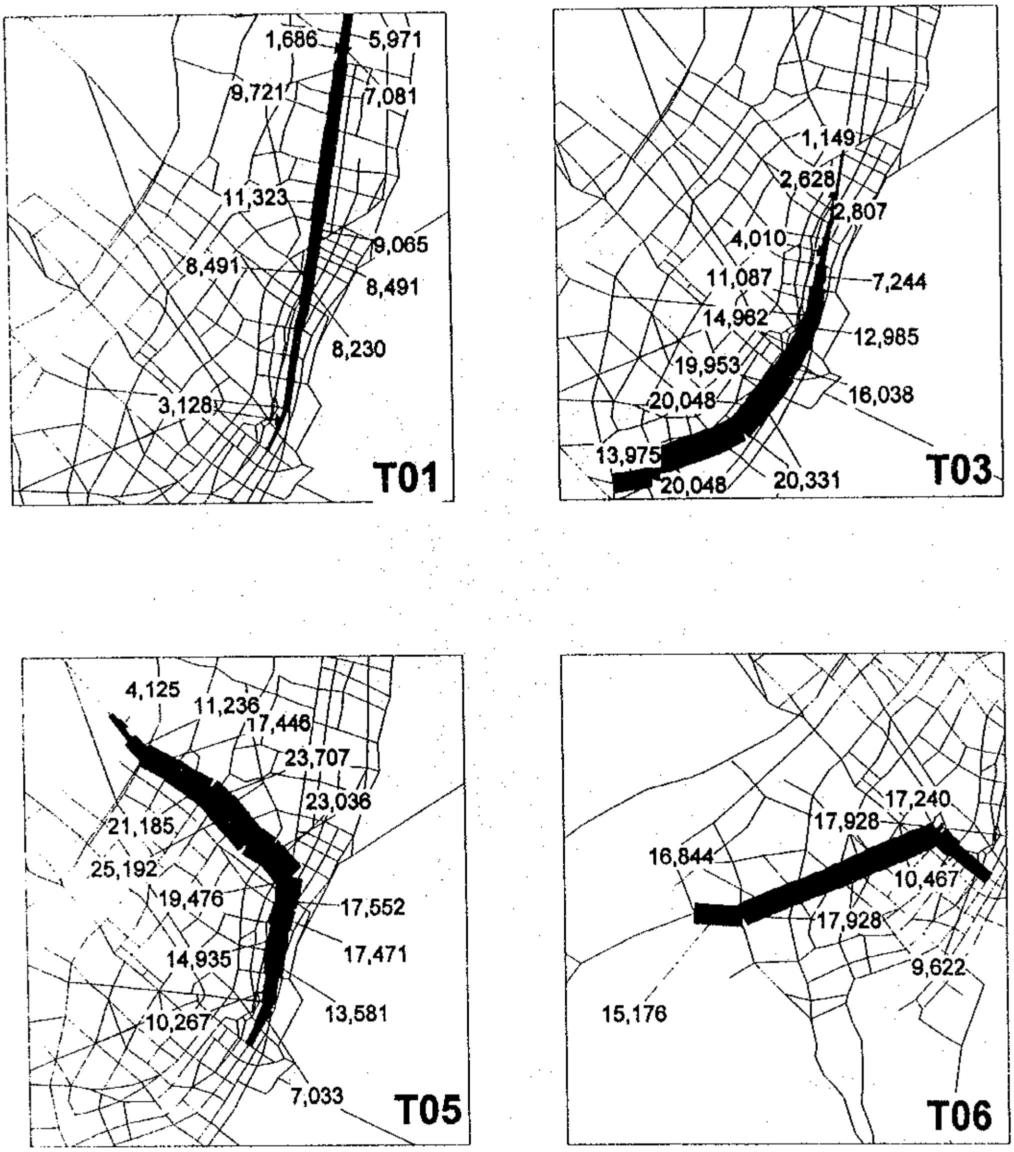


Figure 9.4-3 Trunk Bus Passengers on Board by Route (Inbound) in 2000

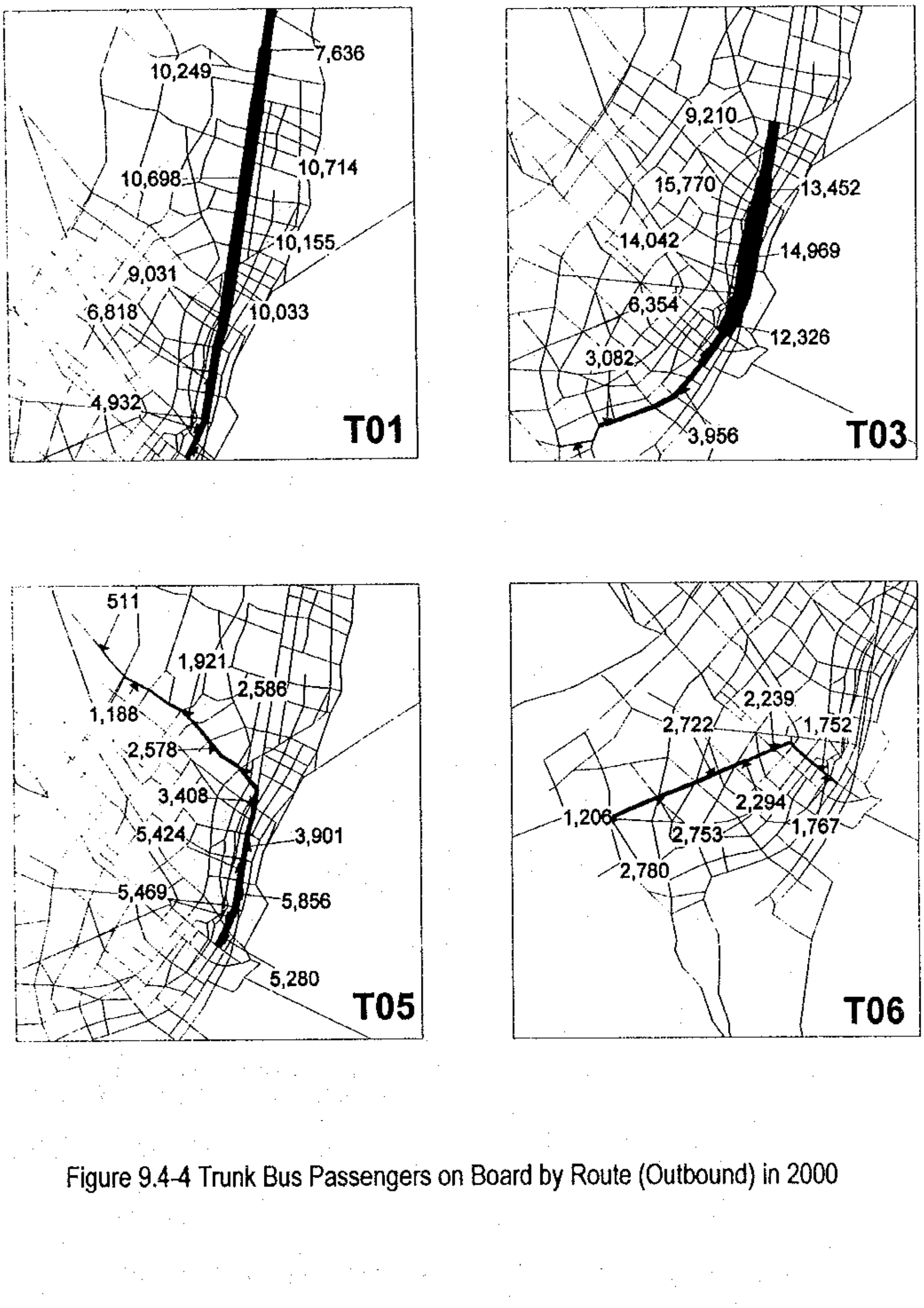


Figure 9.4-4 Trunk Bus Passengers on Board by Route (Outbound) in 2000

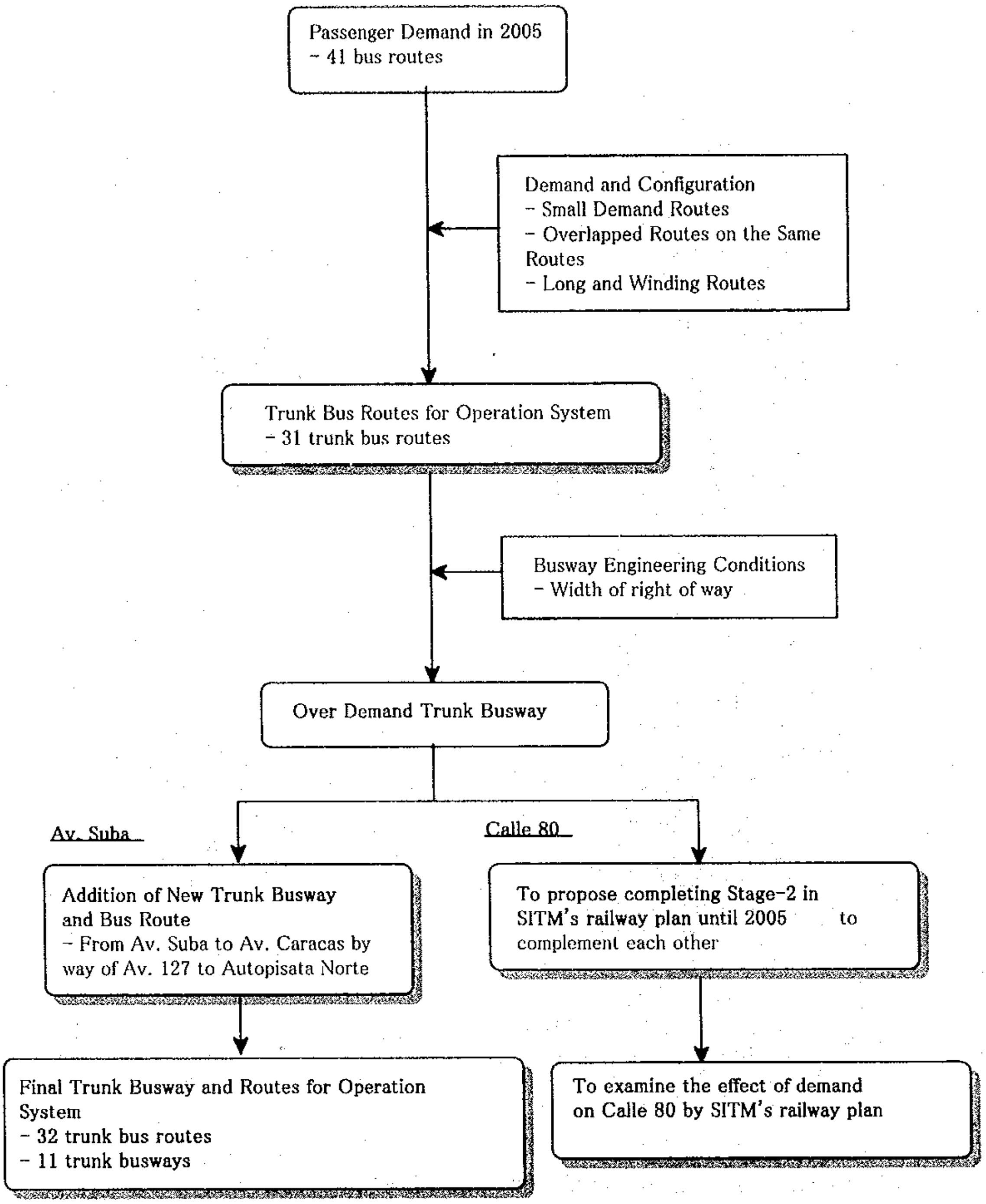


Figure 9.4-5 Examination Flowchart for Operation System in 2005

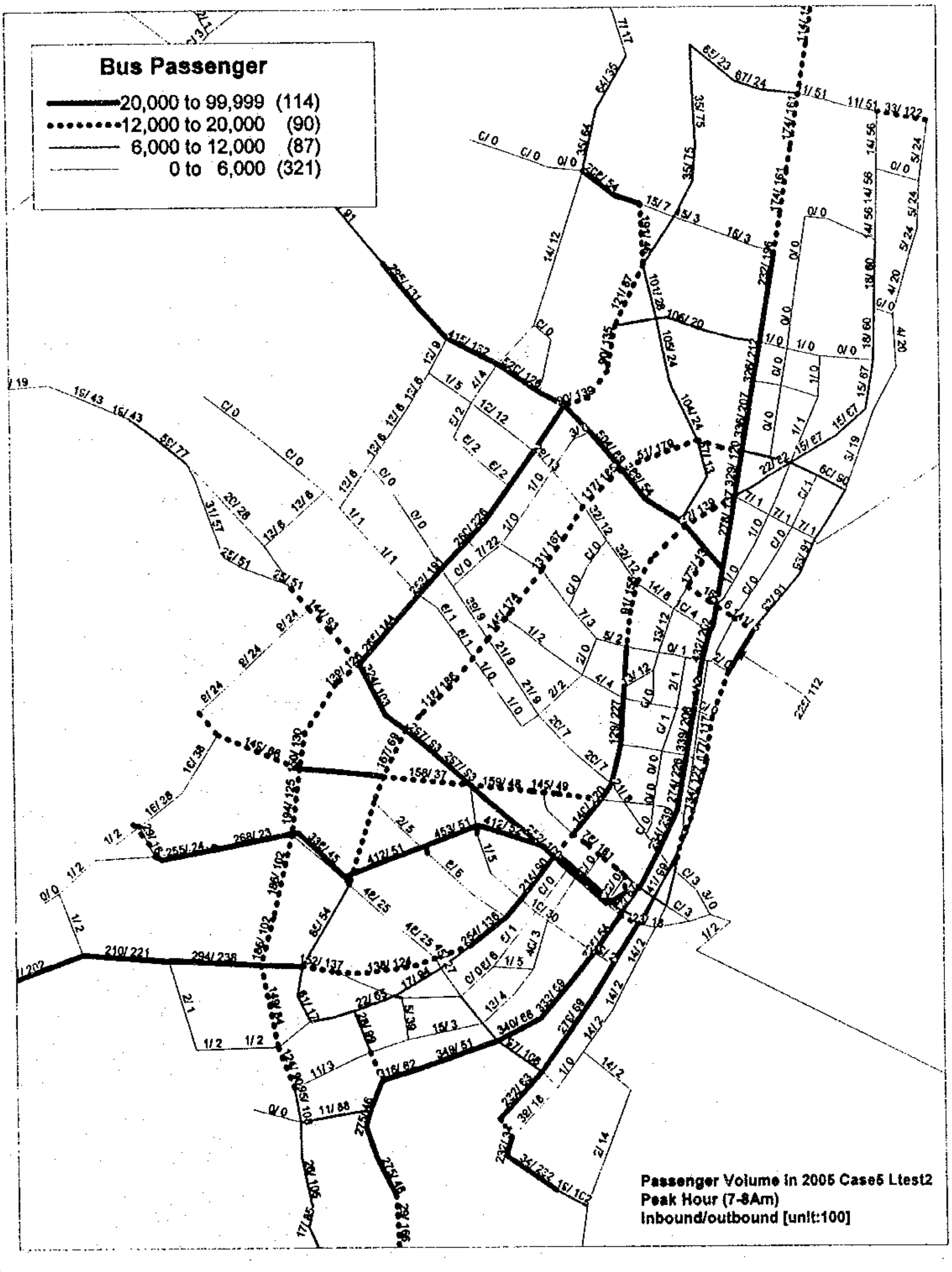


Figure 9.4-6 Peak Hour Bus Passenger Flows in 2005 on Thirty-two (32) Trunk Bus Routes

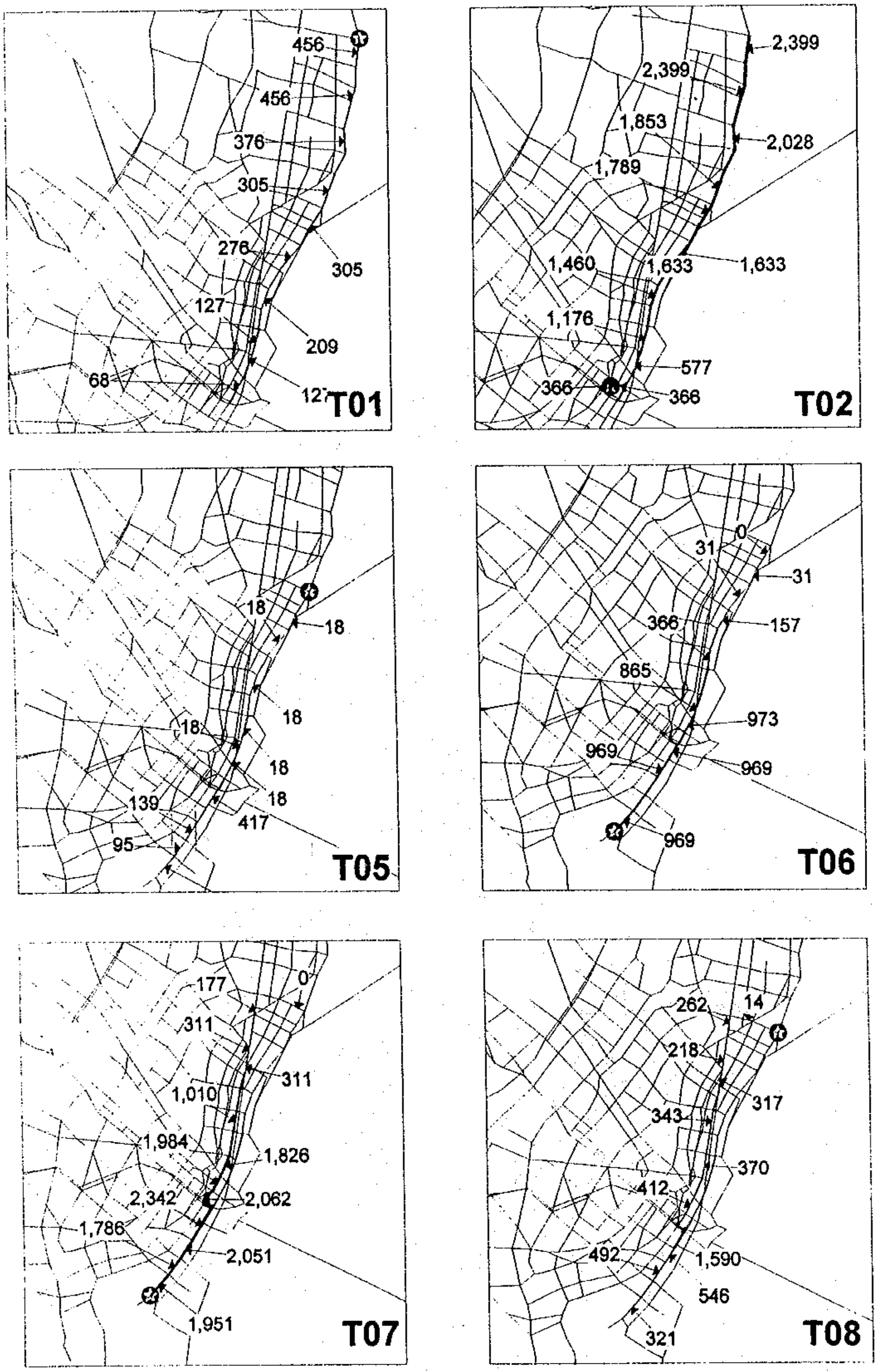


Figure 9.4-7 Trunk Bus Passengers on Board by Typical Route (1) in 2005

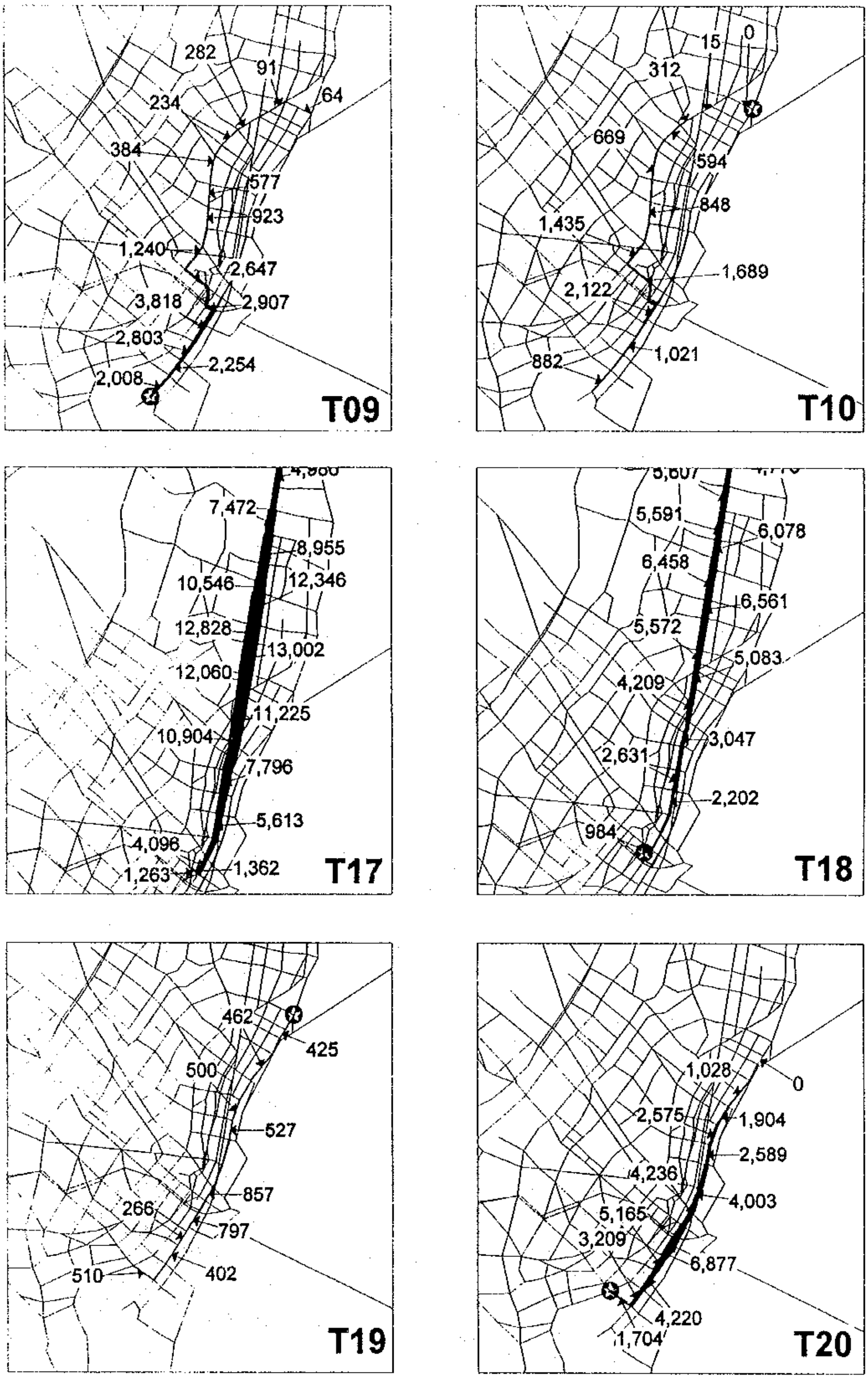


Figure 9.4-8 Trunk Bus Passengers on Board by Typical Route (2) in 2005

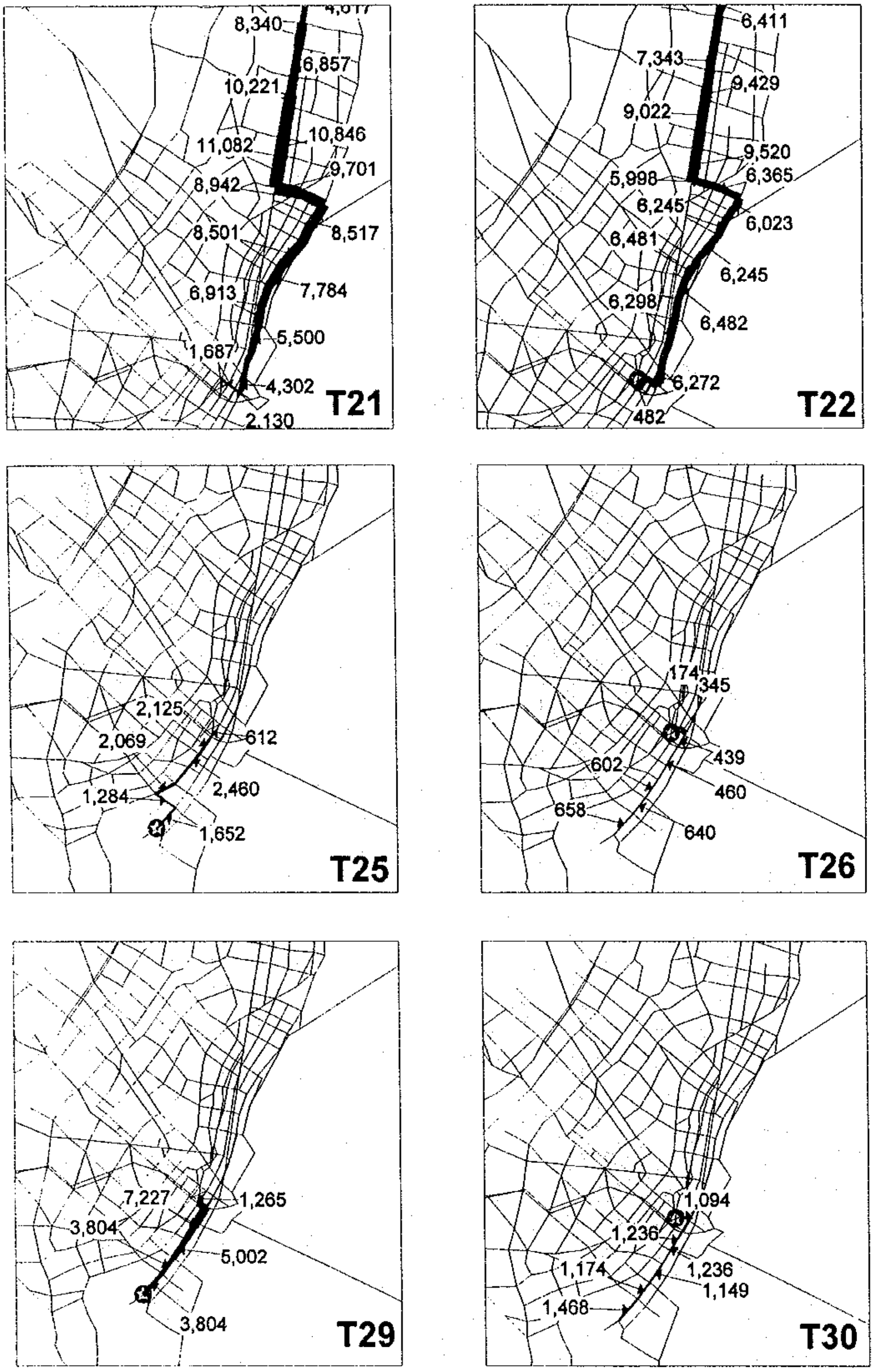


Figure 9.4-9 Trunk Bus Passengers on Board by Typical Route (3) in 2005

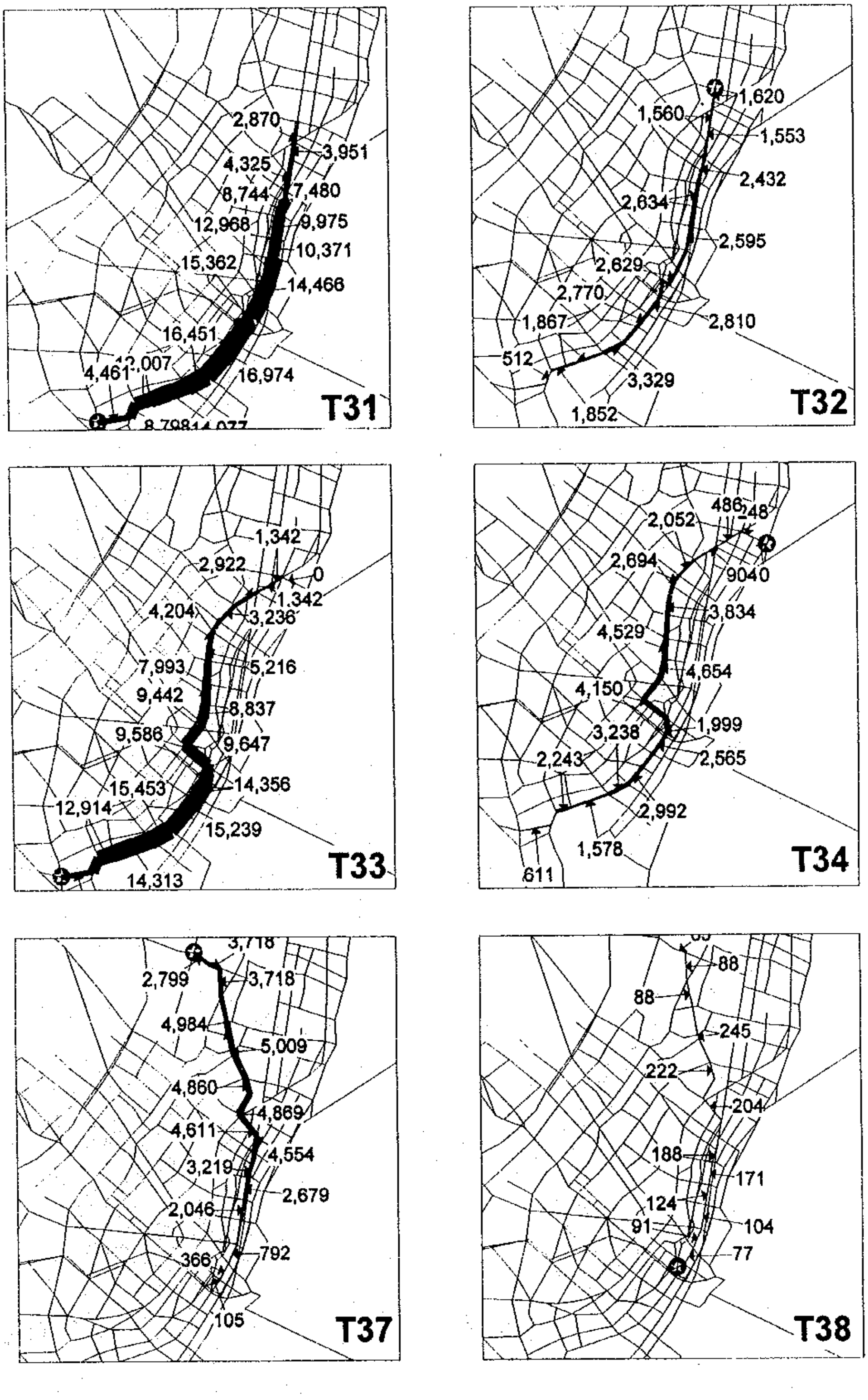


Figure 9.4-10 Trunk Bus Passengers on Board by Typical Route (4) in 2005

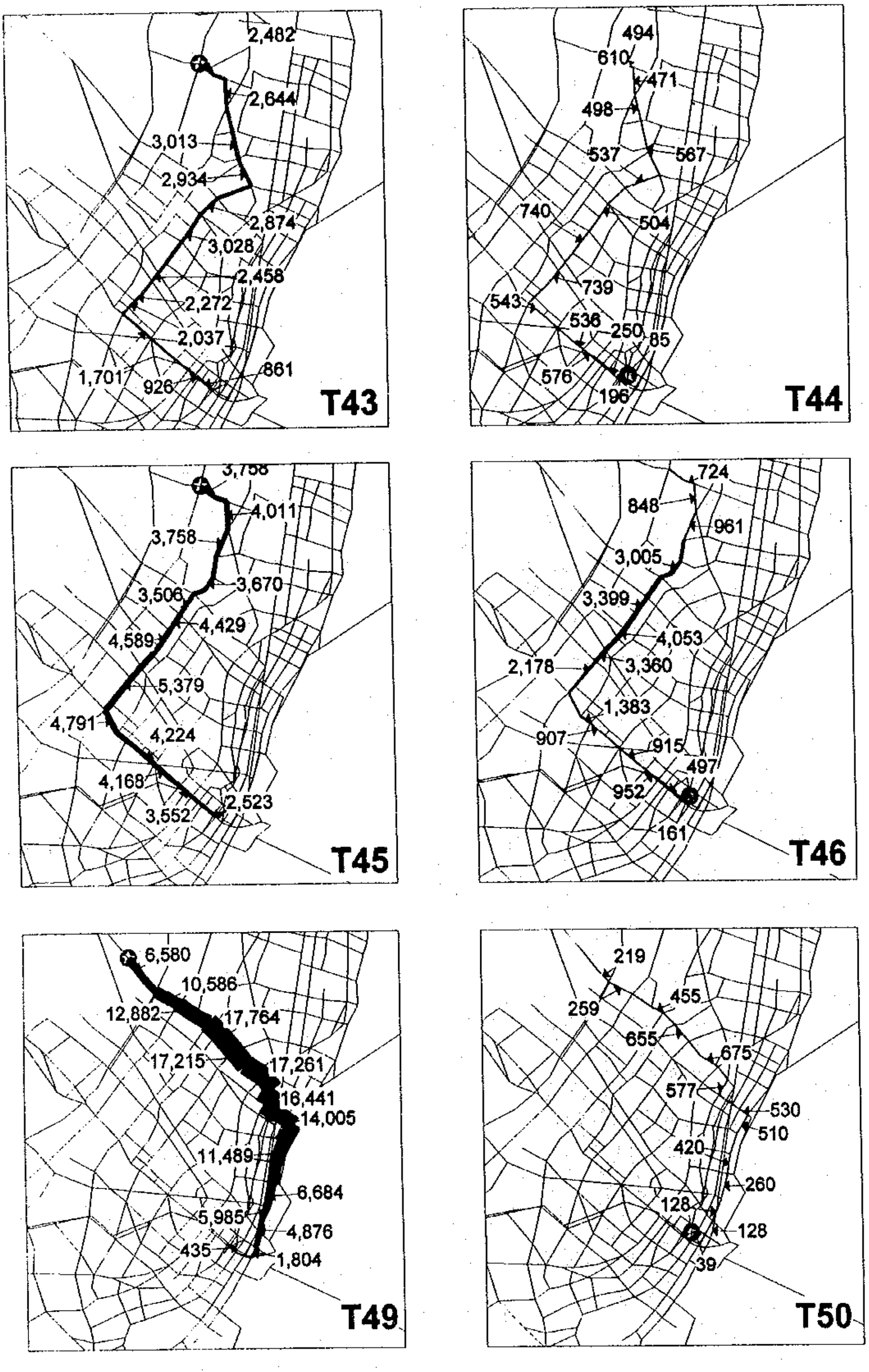


Figure 9.4-11 Trunk Bus Passengers on Board by Typical Route (5) in 2005

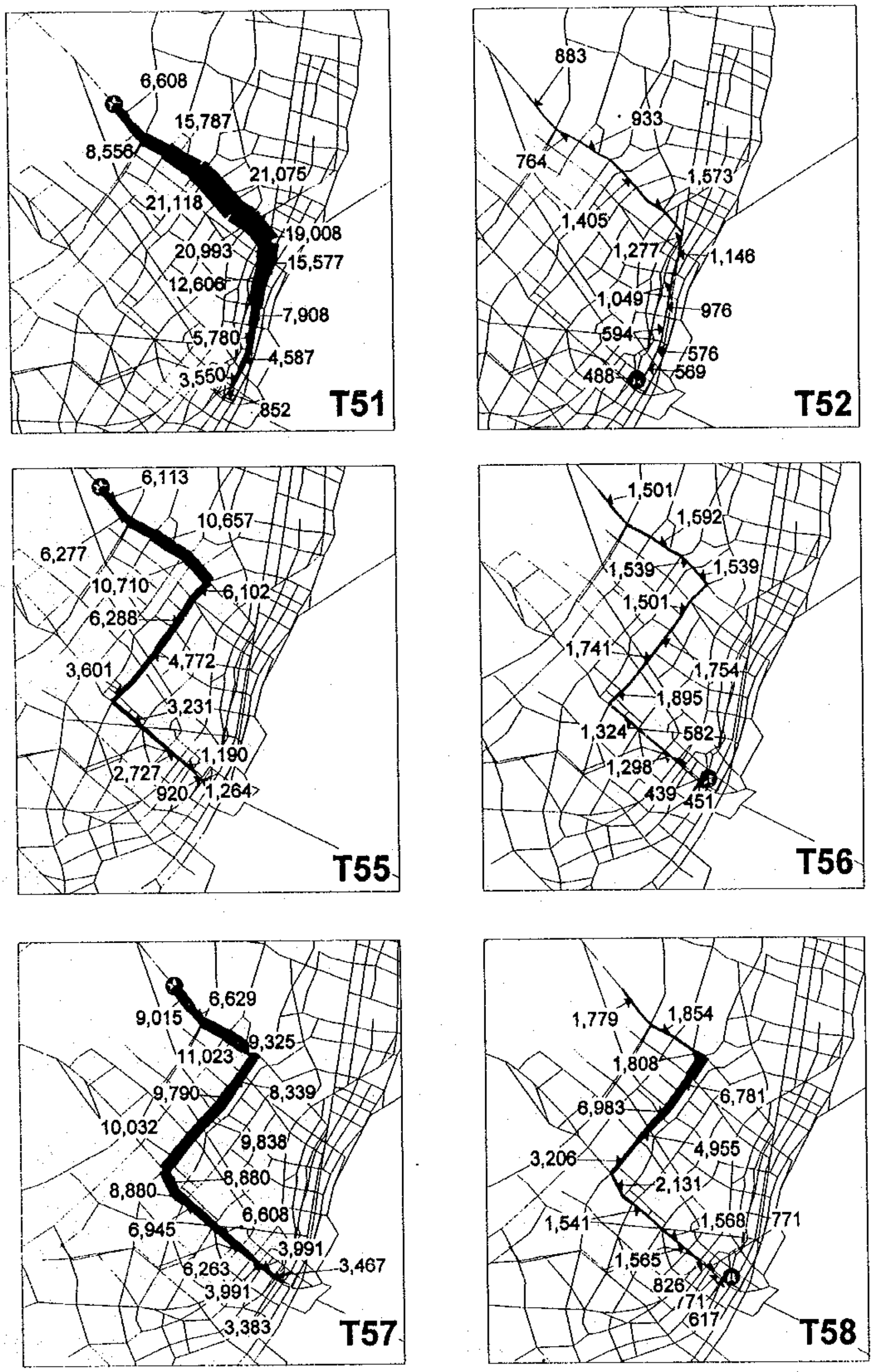


Figure 9.4-12 Trunk Bus Passengers on Board by Typical Route (6) in 2005

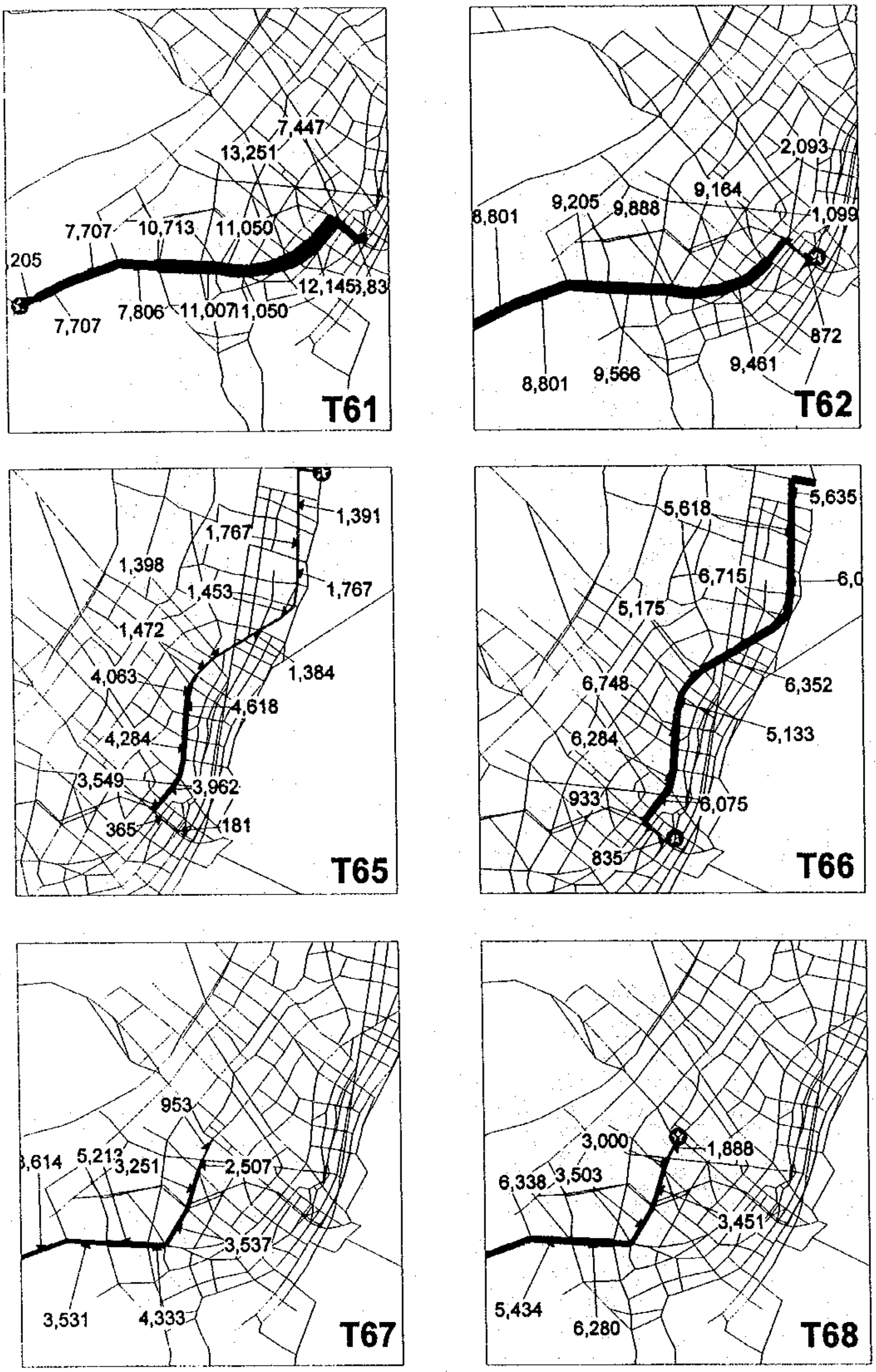


Figure 9.4-13 Trunk Bus Passengers on Board by Typical Route (7) in 2005

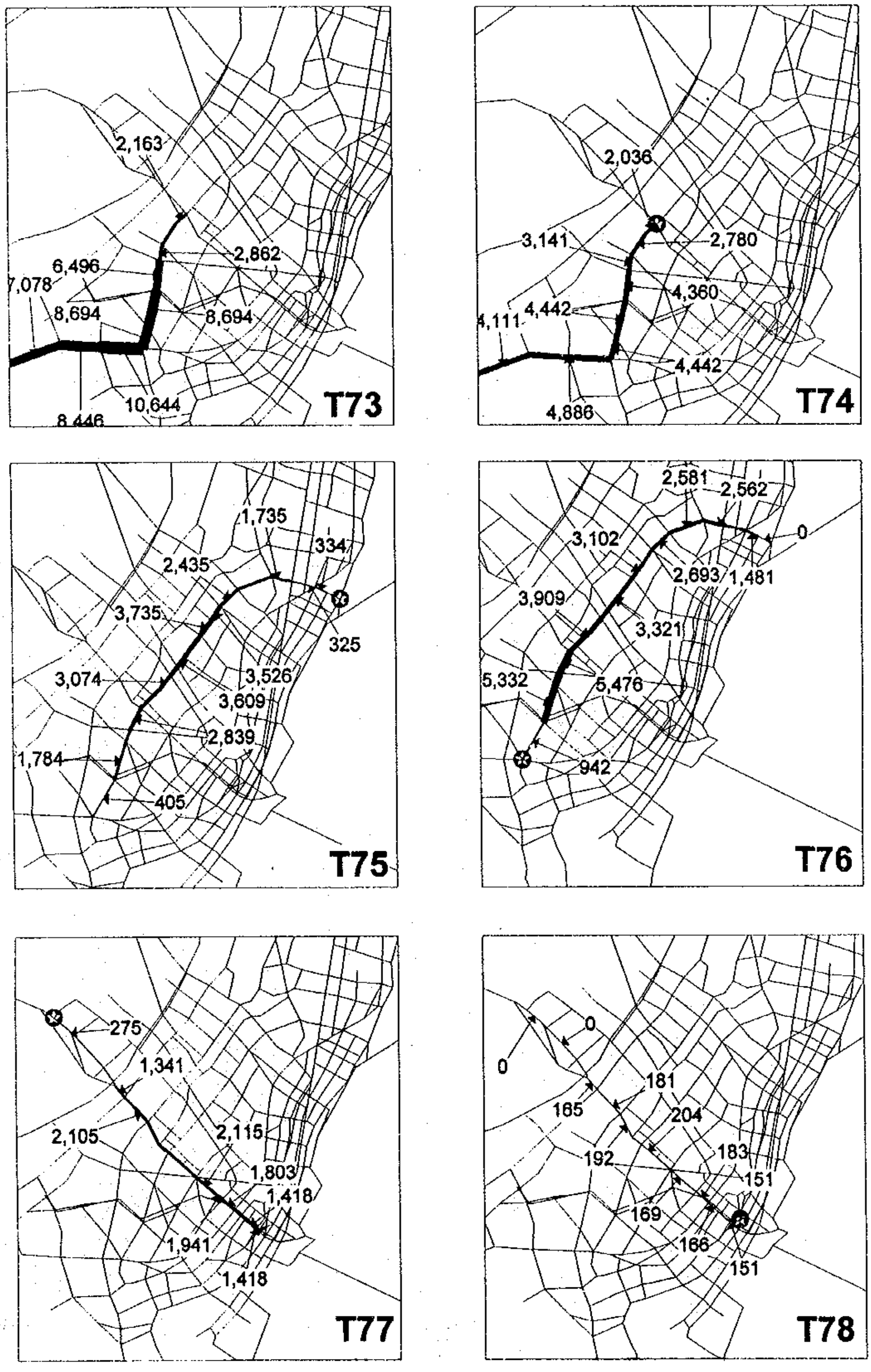


Figure 9.4-14 Trunk Bus Passengers on Board by Typical Route (8) in 2005

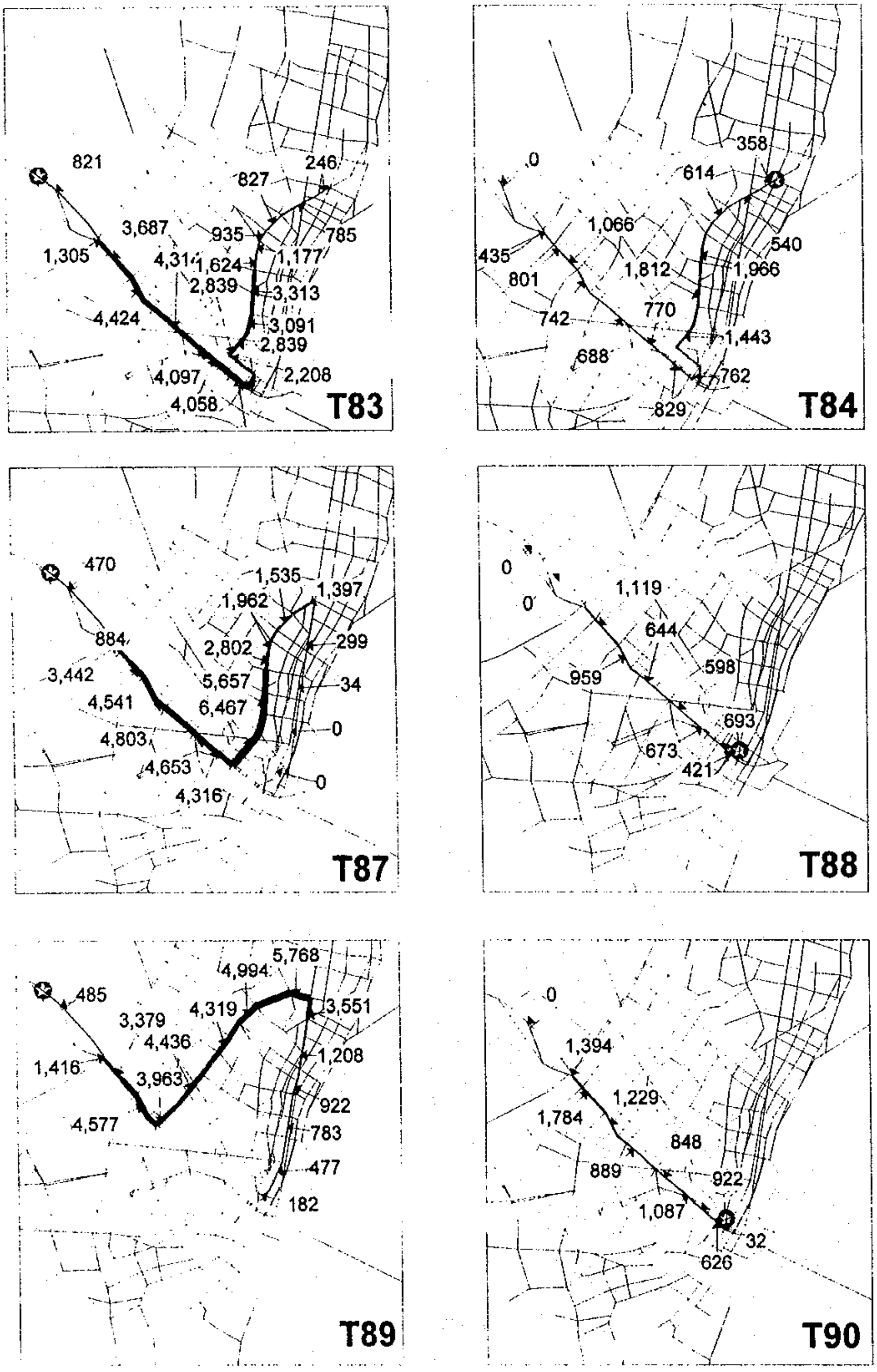


Figure 9.4-15 Trunk Bus Passengers on Board by Typical Route (9) in 2005

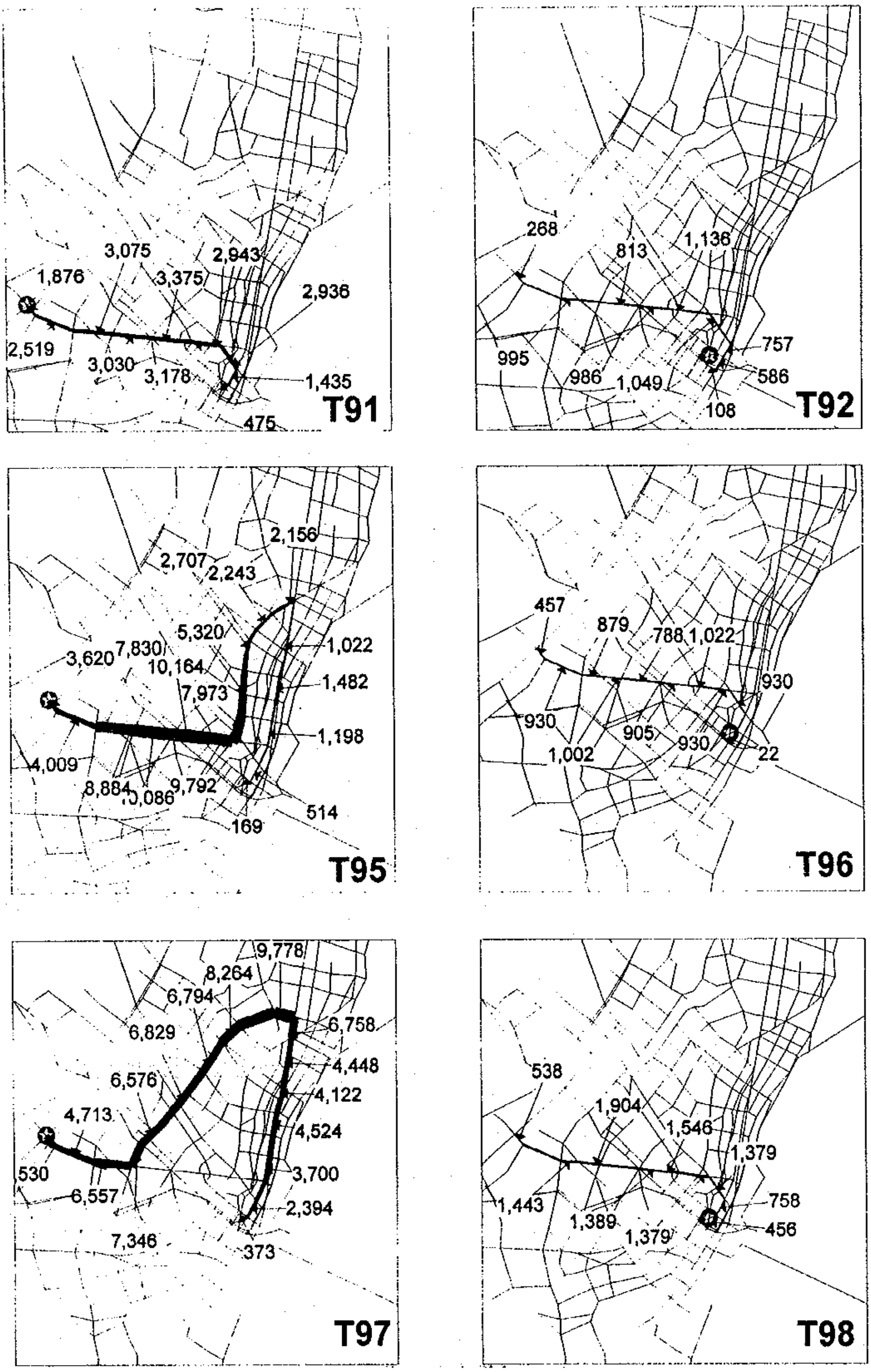


Figure 9.4-16 Trunk Bus Passengers on Board by Typical Route (10) in 2005

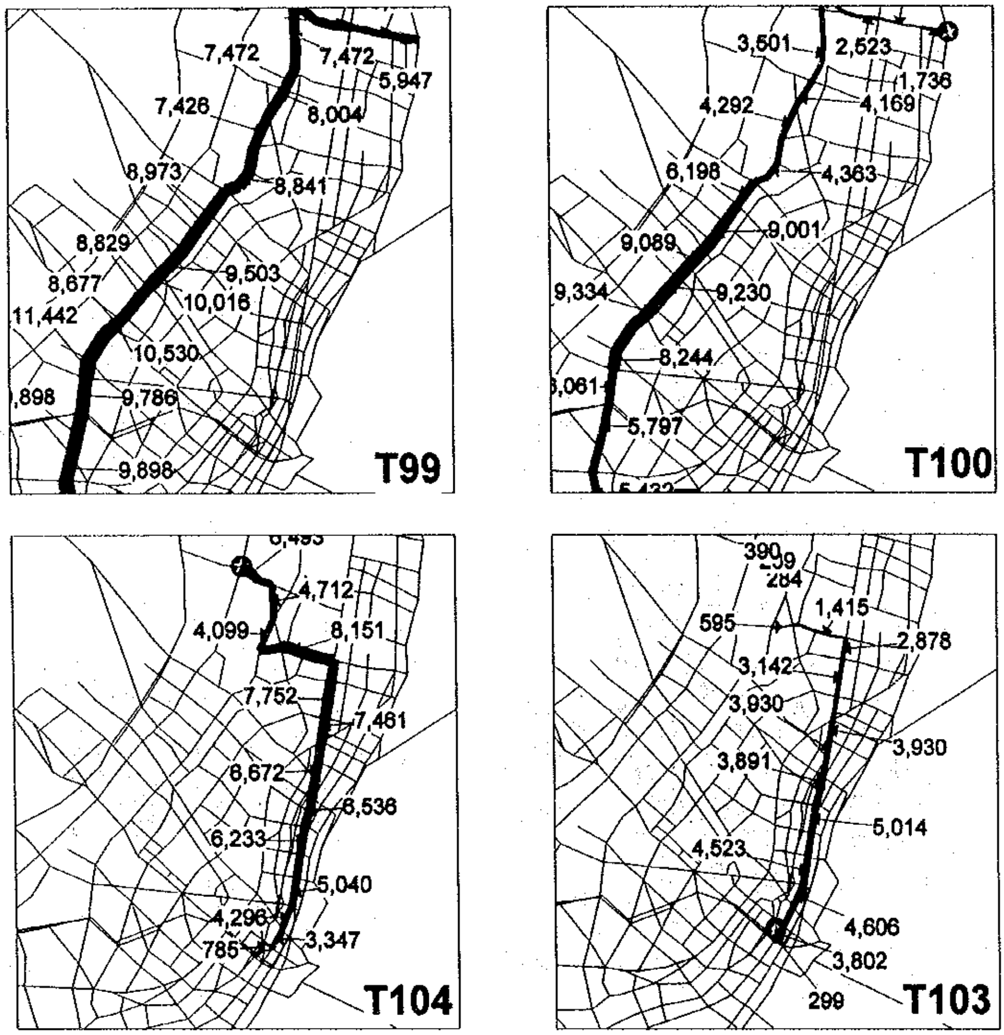


Figure 9.4-17 Trunk Bus Passengers on Board by Typical Route (11) in 2005

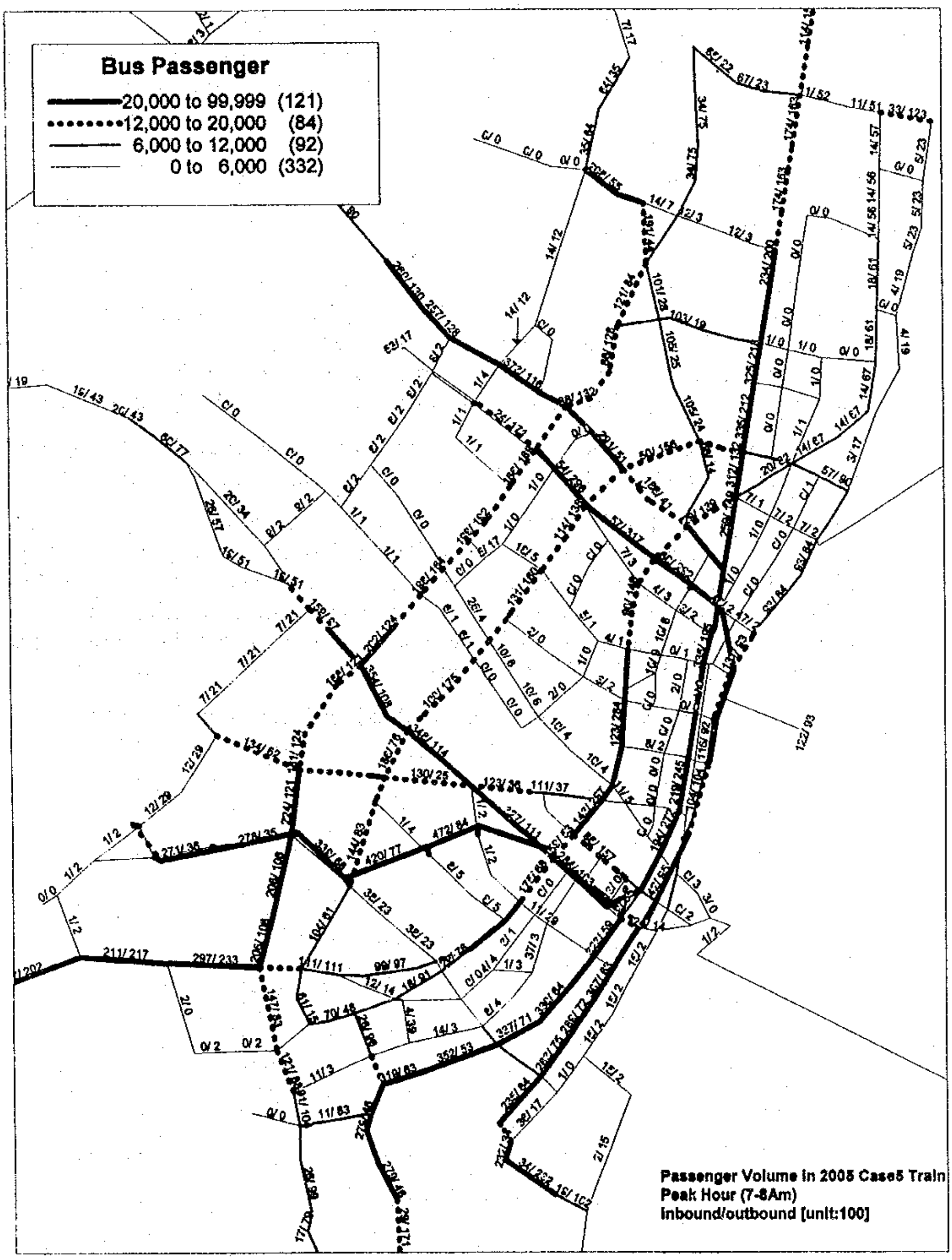


Figure 9.4-18 Peak Hour Bus passenger Flows in 2005 on Thirty-two (32) Trunk Bus Routes with Stage-2 in SITM'S Railway Project

9.5. PROPOSED BUS OPERATION SYSTEM

9.5.1. TARGET HOUR

A target period in the bus operation system is in the morning period between 7:00 and 8:00 a.m. The bus operation system with its components such as scheduled frequency, headway and allocated bus fleets in the morning peak hour is proposed through express and trunk bus service because passenger demand is very heavy and concentrates in the morning peak hour.

9.5.2. EXPRESS AND TRUNK BUSES

Two types of bus service will be provided under the trunk bus system: trunk and express bus services. The purpose of express bus service is to provide a rapid and mass transit service associated with alternative mode of railway transit. Therefore, the express buses run on the fully segregated busways on the elevated roads and /or roads with grade separated intersections. The bus passengers commuting to the city center will use the express buses in the peak hour. In order to provide a high quality service (commercial speed and comfort), buses stop at limited-stop (bus stop spacing of 1.0 – 1.5km) locations.

A large volume of trunk buses are provided, on the basis of a somewhat slow bus operation with a bus stop spacing of 600 to 800 m on the average, compared to the express bus.

As for bus routes designated for the express bus service, the share of express bus service frequency to the total frequency is expected to be 50% according to the opinion survey of bus users. Figure 9.5-1 shows the diversion ratio of express bus from ordinary buses according to time difference between express and other buses with parameter of difference between fare rates. As can be seen, approximately 50% of interviewees chose the express buses, though effect of time difference is not clear.

Table 9.5-1 summarizes the functions and structure of express and trunk bus services.

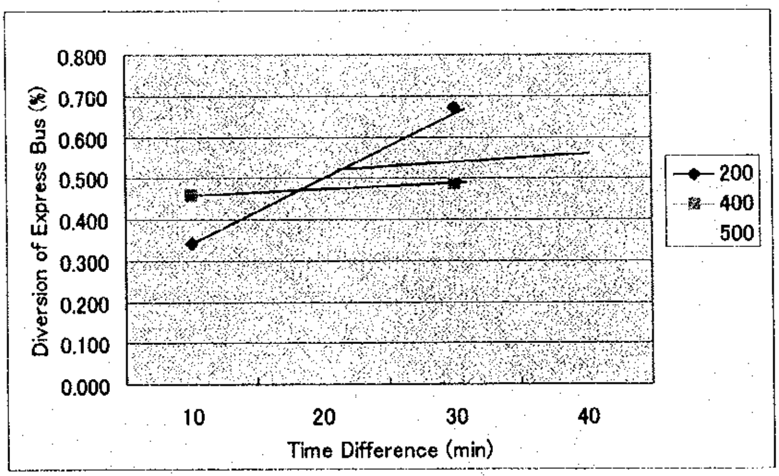


Figure 9.5-1 Diversion Ratio of Express Bus by Opinion Survey

Table 9.5-1 Function and Structure of Express and Trunk Buses

Items		Express Bus	Trunk Bus
Function		Rapid, and great volume	Great volume
Commercial Speed (km/h)		30	20
Bus Capacity (person)		200	100
Busway	Cross Section	Fully segregated busway or elevated structure busway	Bus exclusive lane
	Intersection	Grade separated structure	At grade structure
	Bus Stop Spacing	10.- 1.5km	600 -800 m
Share of Passenger Demand on Same Route		50%	50%

9.5.3. Bus Interior and Capacity

(1) Bus interior and capacity

An important consideration is the number and arrangement of seats, which is based on the trade-off between passenger circulation and seating capacity. For bus routes which seldom have standees, the maximum number of seats should be provided. With standard widths between 2.44 and 2.59m and seat widths of 43 to 49 cm, only about 50 cm remains for aisle width. This is a width that is not sufficient for easy circulation when there are standees, especially while the bus is moving.

In the Buses and Busetas operated in Bogota, two double seats are used for operation. In the peak hour, approximately 60 passengers are carried with, including to 10 and 15 standees, on Av. Caracas. In this situation, the width for those standees is not sufficient for easy circulation.

Since the passenger demand on the trunk bus routes is heavy in the peak hour according to the demand analysis, two double seats should not be used for trunk bus routes that carry standees. A two plus one seating between the two doors is a better layout for such service. For very high passenger volumes single seats (1+1) in the entire buses are preferable, since they offer the highest total capacity.

While the seating capacity is precisely known, standing capacity is a function of the assumed areas per standee. Generally, an area of 0.10 to 0.15 m^2/space per standee is used for structural design of the buses. A realistic value for crush loading is about 0.10 m^2/space. For acceptable comfort levels the area per standee of 0.25 to 0.35 m^2/space (3-4 passengers/ m^2) should be used.

In general, bus capacity is defined as follows:

1) "Seated capacity": the number of seats available to passengers on a bus

2) "Normal capacity": the passenger capacity of a bus at the comfort standards considered "normal" in each city; this typically means the seated capacity plus standees at a density of 6-9 passengers/m^2, depending upon the city.

3) "Crush capacity": the total number of passengers which can physically be accommodated in a bus; this varies slightly from city to city, depending upon

passenger characteristics, social conventions and so on; crush capacity typically includes standees at 10+ passengers/m^2.

Table 9.5-2 shows bus capacity in Curitiba, Brazil and Nagoya, Japan where trunk bus systems are introduced. In Curitiba, a single-body bus with a bus capacity of 110 passengers is used for trunk bus, and articulated buses with a capacity of 160 for two bodies and 270 for three bodies are used for express buses. In the Nagoya Key Route Bus System, a single-body bus is operated on the trunk busway. The total capacity is 73 passengers with 27 seats. In Curitiba, the values of 8-10 passengers/ m^2 are used for the standing capacity, while 6-7 passengers/ m^2 are used in Nagoya. Those figures are close to the "Normal capacity".

Transversal seating is more comfortable than longitudinal because people are more sensitive to lateral than to forward /backward forces. Since transversal seats also give more privacy, they are used wherever possible. For comfort and safety of standees, buses should have as many stanchions and holding bars, that a person can catch one from any standing location.

Figure 9.5-2 to Figure 9.5-4 show the seat layout of trunk buses used in Curitiba and Nagoya. Transversal seating is used for those buses in both cities.

(2) Proposed bus capacity in the trunk bus system

In Bogota, bus transport is main mode for public transport and public transport demand is heavy, especially in the peak hours. When the trunk bus system is introduced in Bogota, larger buses on the trunk busway will offer both lower operation cost and higher service reliability.

The general merits of large buses are as follows.

1) Operation costs per unit of offered capacity decrease as bus fleet size increase.

2) Line capacity increases nearly linearly with bus size. With larger buses, street congestion decreases and reliability of service increases.

3) Vehicle maneuverability decreases with bus size.

4) Riding comfort increases with the bus size of single-body buses, but is lower with articulated and double-decker buses.

Table 9.5-3 shows the bus capacity proposed in the trunk bus system. A single-body bus with a bus capacity of 100 passengers is used for trunk bus. Articulated bus with two bodies whose capacity is 200 is used for express buses. A density of standees refers to the capacity in Curitiba. The passenger capacities of trunk and express buses are almost 2 – 4 times, compared to the current bus capacities.

The passenger load factor in terms of the number of people per bus, will exceed 1.00 in the peak hour.

Table 9.5-2 Bus Capacity in Curitiba, Brazil and Nagoya, Japan

Type of Bus	Passenger Capacity			Body Size			Seat Layout
	Seats	Standees *)	Total	Length (m)	Width (m)	Height (m)	
1) Curitiba, Brazil							
Express Padron	30	80	110	12.46	2.54	2.97	Tranversal Seat
Express Articulated	48	112	160				
Express Biarticulated	57	213	270	24.52	2.50	3.42	
2) Nagoya, Japan							Tranversal
Key Bus	27	46	73	10.64	2.49	3.07	Seat with 2+1

Note: *) Standee density is 8-10 passengers/m^2 in Curitiba
Standee density is 6-7 passengers/m^2 in Nagoya

Table 9.5-3 Proposed Bus Capacity for Trunk Buses

Type of Bus	Seats	Standees	Total
Trunk Bus	30	70	100
Express Bus *)	60	140	200

Note: *) Articulated Bus

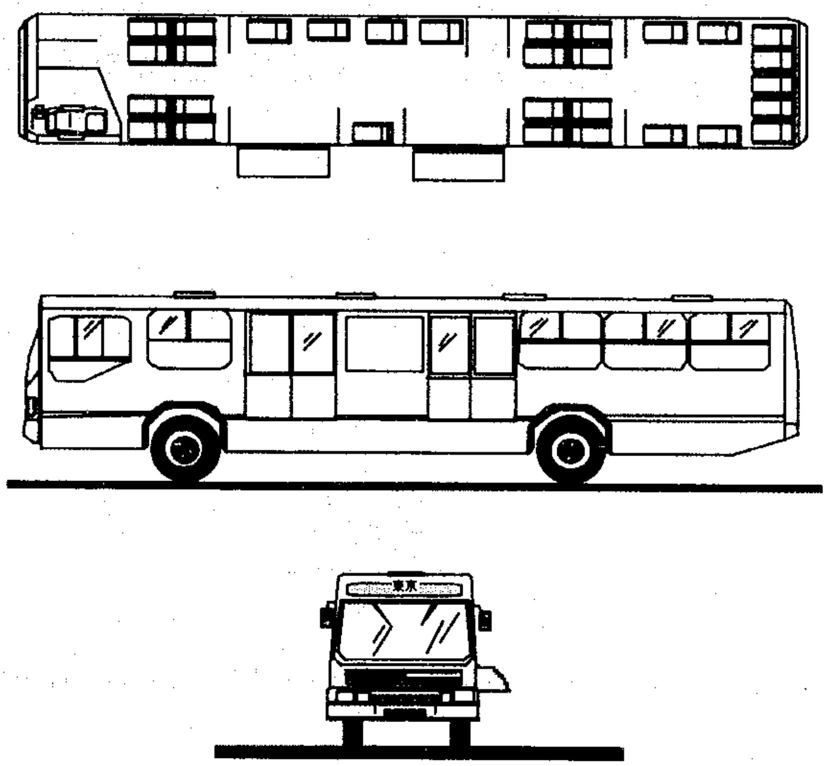


Figure 9.5-2 Seat Layout for Buses in Curitiba, Brazil (Express Padron)

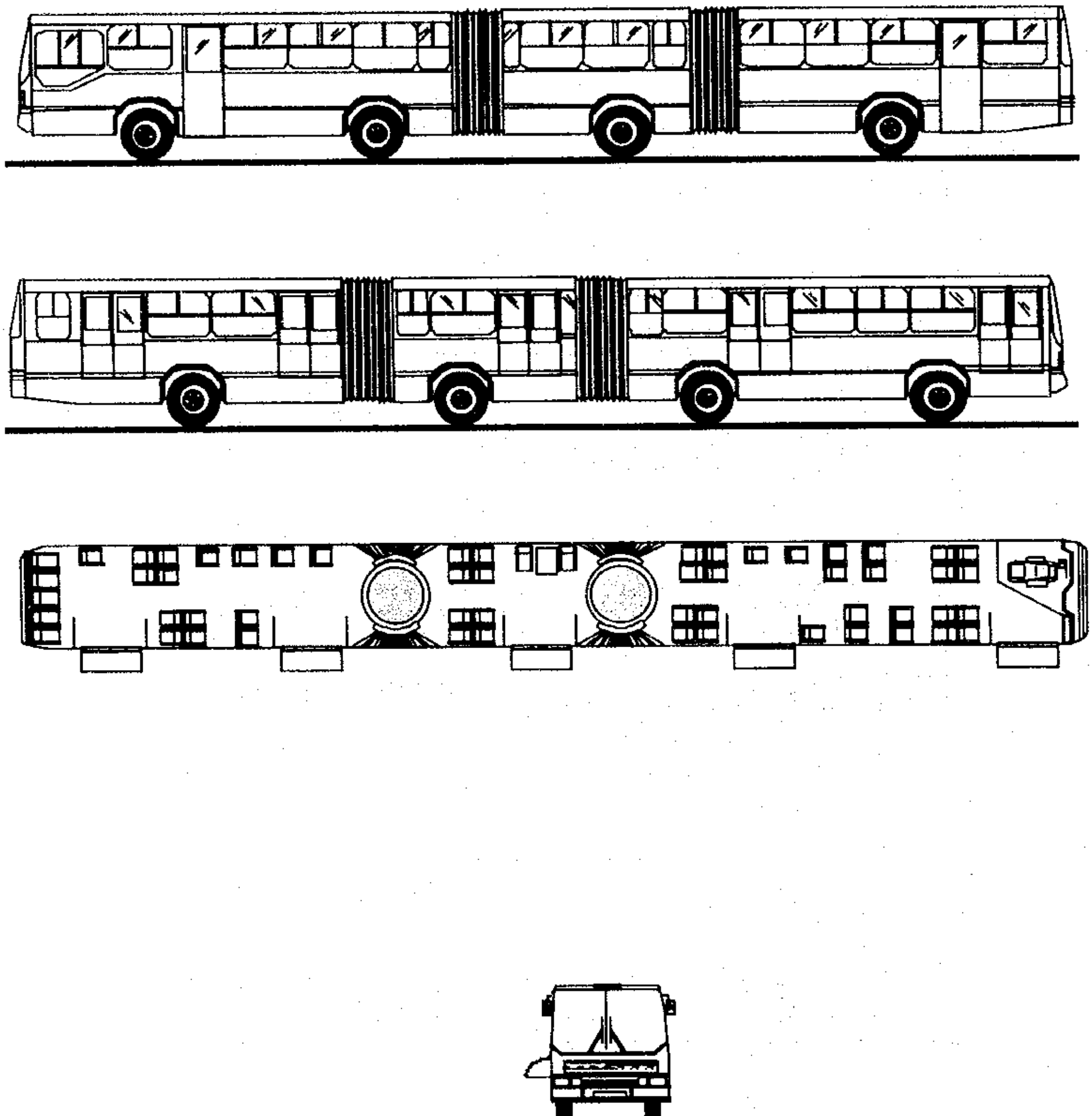


Figure 9.5-3 Seat Layout for Buses in Curitiba, Brazil (Express Biarticulated)

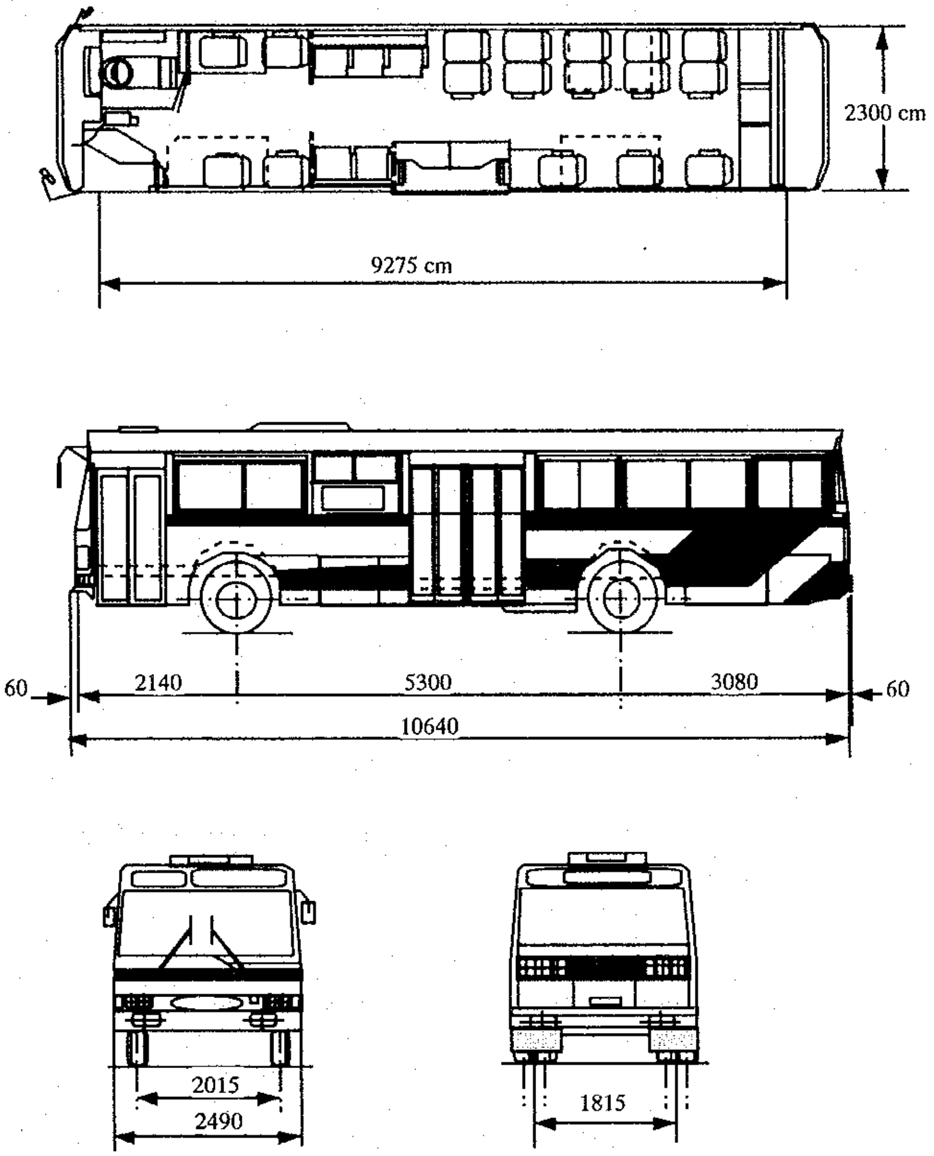


Figure 9.5-4 Seat Layout for Bus in Nagoya, Japan

9.5.4. Bus Commercial Speed

Figure 9.5-5 summarizes an accumulative percentage of distribution of bus commercial speeds recorded along Av. Caracas with segregated busway in the morning peak. The data were recorded during September and October 1998, when vehicle number plate control already has been commenced in Bogota, and traffic conditions on the vehicle lanes outside segregated busway have been improved.

As can be seen, the commercial speed of 50 percentile of bus is approximately 17km/h in the morning peak. The figure varies along sections of south, central and north districts. The section between Calle 26 and Calle 76 in inbound direction is as low as 7 to 15km/h. The highest speed is nearly 35km/h.

According to other records, referred to in Research Report 329 of TRRL, on the Av. Cristiano Machado busway in Belo Horiz, Brazil where nearly 30km/h were recorded in the morning peak. The bus stop design of the busway allows bus overtaking, some buses operate express service, and bus stop and intersection spacings are long. In Curitiba, commercial speeds were recorded between 20 and 25km/h in both peaks. In Nagoya, Japan the commercial speed on the key route bus is approximately 20km/h.

In the Study, on the assumption that the commercial speeds of express and trunk buses are approximately 30 and 20km/h, the bus operation system and busway structures are planned. Table 9.5-1 summarizes the outline of busway structures.

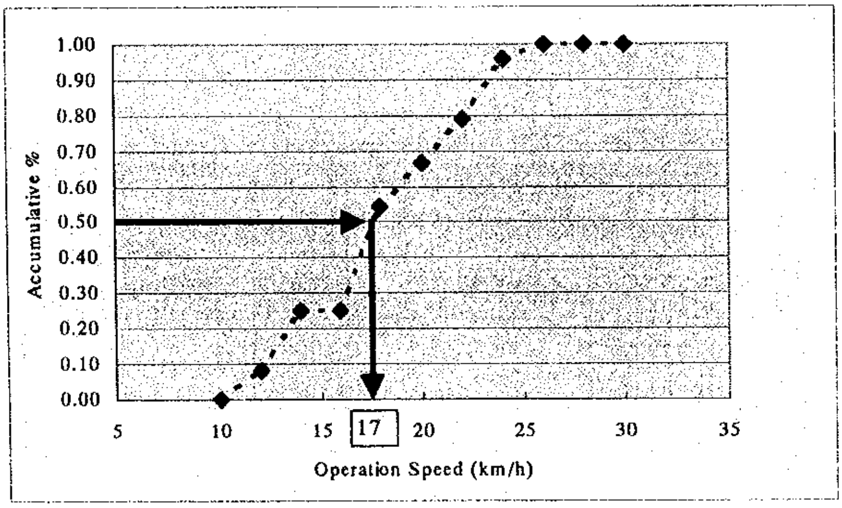


Figure 9.5-5 Bus Commercial Speeds on Caracas in the Morning Peak

9.5.5. Bus Stop Spacing

The main physical determinations of average bus commercial speed appear to be bus stop and intersection spacing. Bus stop capacity is an important determinant of overall bus system performance. Bus stop spacing also influences performance. Regarding the relationship between bus stop spacing and commercial speed from the Design Guideline for Busway Transit in Transport Research Laboratory (TRL), the longer the stop spacing is, the higher the commercial speed is. For example, the commercial speed rises at approximately 1.3 – 1.4 times, when the spacing is longer than 600m to 1km.

The spacing for express bus service employs an average spacing of 1.5 km, while an average spacing of 600m is for trunk bus (see Table 9.5-1).

As for the Key Bus System in Nagoya, Japan, the average spacing for express bus is approximately 700m, while 400m is for the key bus.

9.5.6. Ticketing System

The passengers have to pass through turnstile before paying the bus fare at entrance door of the bus under the current ticketing system. On the system, for instance, it takes 5 to 10 seconds for 2 –3 passengers at boarding and alighting. Therefore, in order to reduce the dwelling time at bus stop, an efficient ticketing system is needed. Boarding times per passenger, in a fare collection system in which entry to a bus is unobstructed by fare collection or ticket validation, are lower than those of the current system in which entry is restricted.

In Curitiba, a conductor who rides on a bus handles ticketing inside of a bus. The dwelling time on this ticketing system is shorter than that on the current system in Bogota.

The proposed commercial speeds of trunk and express buses are on the assumption that an off-board ticketing system as well as a quick ticketing system is employed. It offers the possibility to reduce passenger service time and thereby to reduce bus dwelling time and increases commercial speed.

9.5.7. RELIABILITY OF BUS SERVICE

In general, the reliability of bus service is usually measured as a percentage of arrivals at the terminus with 0 to 4 minute delay. It also depends primarily on traffic conditions along the route. Buses have high reliability under certain conditions. For example, if streets are blocked, bus routes can be quickly and easily relocated. Further, buses are not affected by temporary power failures.

On the negative side, buses are highly sensitive to traffic conditions, since the majority of bus routes operate on roads with mixed traffic. Inclement weather affects buses much more than rail mode. Consequently, bus services in congested urban areas with a reliability of only 50 to 70% are not rare, particularly during peak hours.

In the proposed trunk bus system, since trunk and express buses are operated on the busways segregated from private vehicles, the buses are not influenced by traffic conditions. The reliability will be improved, compared to the current system.

Regularity of bus operation can be improved if a central control is introduced which can monitor movements of all buses on a route or an entire network. Central control of buses is, however, more technically difficult and more complex, owing to the large number of buses and complicated route network. Those controls measures can be very useful in correcting the delays. Therefore, It is possible to increase the reliability.

9.5.8. OPERATION SYSTEM IN 2000

(1) Procedure

As mentioned before, in order to examine the actual trunk bus operation, the several trunk bus routes are cut or integrated. Finally the four (4) routes in 2000 and thirty-two (32) routes in 2005 are proposed as trunk bus routes. According to the passenger demand on these routes, bus operation system in the peak hour with components such as scheduled frequency, headway and allocated bus fleets is proposed through express and trunk bus service. The number of allocated bus fleets, the number of provided bus fleets by trunk and express buses including purchase of a bus fleet are also discussed.

The bus operation system is examined according to the following assumptions:

1) In general, there are two (2) scheduled service frequencies: one is for the frequency decided by a transport policy and the other is by demand. The frequency employed should be the larger of the two frequencies. In Bogota, since the demand is large, the frequency is decided by the maximum demand on a route.

2) A scheduled service frequency is calculated by dividing the maximum demand by bus capacity.

3) A share of express bus service frequency to total service (express and trunk buses) will be 50% in case of a route with service of express and trunk buses.

4) A dwelling time at bus stop is reduced on the assumption that an off-board ticketing system as well as a quick ticketing system is employed. A reduction ratio of 50% of the dwelling time to that of the current bus with 2-doors is employed,

referred to dwelling time recorded in U.S.A. in which boarding time by paying on board is 6- 8 sec, as compared to 1.5 – 2.5 sec for an off-board ticketing system. The factor of express bus with 4-doors is 0.25.

5) Operation headway is decided, assuming that a dwelling time is shorter than that of headway,

6) The scheduled frequency with a round-trip route employs the larger frequency of the two directions.

(2) Demand and Trunk Busway Plan

Table 9.5-4 shows trunk busway plan according to passenger demand on each busway. In 2000, the trunk bus passenger flows on Caracas in the peak hour are 20,000- 30,000 /h/d in the inbound direction. On Calle 80 approximately 24,000 passengers/h/d in the inbound direction pass through. Autopista Norte and Ferreo de Sur are also busy in passenger flows. Therefore, the 1-lane trunk and express busways /dir on Av. Caracas-Norte and Calle 80 are planned according to demands on busway. On Calle 80, 2-lane/dir busway is under construction now. Ferreo de Sur needs 2-lane trunk busway in one direction.

In 2000, elevated busway on Av. Caracas will be planned for the express bus system.

Table 9.5-4 Demand and Trunk Busway Plan in 2000

Busways	Bus Passengers/hour			Type and No. of Lanes/dir.	Remarks
	Total (Trunk+Ordinary)	Trunk Buses	Ratio of Trunk		
Autopista Notre	20,000	11,000	55.0%		Existing right of way: 100m
Caracas in south	29,000	20,000	69.0%	1-lane trunk busway/dir and 1-lane express busway/dir	ROW: 40 m
Caracas in central	35,000	30,000	85.7%		ROW: 40 m
Calle 80	28,000	24,000	85.7%	1-lane trunk busway, and 1-lane express bus	Under construction of trunk busways with 2-lane /dir.
Ferreo de Sur	19,000	19,000	100.0%	2-lane trunk buway	

(3) Scheduled Frequency and Headway

Table 9.5-5 summarizes the scheduled frequency and headway in the peak hour. The highest frequency in both the express and trunk bus operation is estimated on route No.T05. These figures show a frequency of approximately 60 /hour for the express bus and 130 for the trunk bus. Those headways of express and trunk buses are approximately 60 sec and 30 sec, respectively.

Table 9.5-5 shows the work utilization coefficient a as the ratio of passenger-km carried (utilized service) to space-km operated (offered service). The higher this coefficient is, the better is the system utilization and the more economical is its operation. Higher utilization, however, also indicates lower passenger comfort. In 2000, the maximum coefficient is estimated on route No.T06. The figure is approximately 0.85 which includes bus route in the outbound direction. Both of routes T03 and T05 are as low as 0.5.

Table 9.5-5 Scheduled Frequency, Headway and Work Coefficient in the Peak Hour in 2000

Routes	Direction	Passengers on Board/hour		Scheduled Frequency /dir/hou			Headway (sec)			System Capacity (pax/h)			Ratio of Demand/ Capacity	Passenger -km	Space-km	a=Pax-km/Space-km
		Maxmum passengers	Minimum passengers	Express Buses (200 pax)	Trunk Buses (100pax)	Total	Express Buses	Trunk Buses	Express and Trunk Buses	Express Buses	Trunk Buses	Route Total				
T0001	Inbound	11,578	1,686	29	58	87	124	62	41	5,800	5,800	11,600	0.998			
	Outbound	11,141	3,842	28	56	84	124	64	43	5,800	5,600	11,400	0.977	394,963	661,250	0.597
T0003	Inbound	20,331	1,149	51	102	153	71	35	24	10,200	10,200	20,400	0.997			
	Outbound	15,770	915	40	79	119	71	46	30	10,200	7,900	18,100	0.871	363,963	689,150	0.528
T0005	Inbound	25,192	4,125	63	126	189	57	29	19	12,600	12,600	25,200	1.000			
	Outbound	5,856	511	15	30	45	57	120	80	12,600	3,000	15,600	0.375	306,606	650,760	0.471
T0006	Inbound	18,685	9,622	-	187	187	-	19	19	-	18,700	18,700	0.999			
	Outbound	2,780	1,206	-	28	28	-	129	129	-	2,800	2,800	0.993	247,680	290,250	0.853

(4) Trunk Bus Flows on Busways

Table 9.5-6 summarizes the frequency and headway integrated on the trunk busways. Those figures show larger bus flows in both directions, which are mainly in the inbound direction. Av. Caracas is very busy in bus transport. The total numbers of buses are approximately 430 /hour, of which 140 are for express and 290 are for trunk buses in the peak hour. On Calle 80, the number of buses is 190 /hour at an average of 20-sec headways (57-sec headways for express and 29-sec for trunk buses).

Table 9.5-6 Trunk Bus Flows on Busways in 2000

Busways	Frequency/hour			Headway (sec)		
	Express Buses	Trunk Buses	Total	Express Buses	Trunk Buses	Total
Caracas	143	286	429	25	13	8
Norte	29	58	87	124	62	41
Calle 80	63	126	189	57	29	19
Ferreo de Sur	-	187	187	-	19	19

(5) Allocated Bus Fleets in Peak Hour

Table 9.5-7 shows the number of allocated bus fleets per hour in the peak hour which is estimated taking into account a round trip operation to return to a starting terminal. The total number of allocated bus fleets is approximately 940/hour in the peak hour, of which 190 are express buses and 750 are for trunk buses.

Considering the factors of maintenance and reservation of bus fleets, assuming a factor of 1.2, it is necessary to provide a total bus fleet of 1,100 of which 200 are express buses and 900 are for trunk buses. Articulated buses as well as express buses will need to be newly purchased. As for trunk bus, it is better to use the existing large sized buses as a trunk bus. However, in order to increase a bus capacity, they need to remodel bus interiors with rearrangement of seat layout.

It is necessary to newly purchase articulated buses of 200 capacity and to remodel a large number of approximately 900 buses by the year 2000.

Table 9.5-7 Numbers of Allocated Bus Fleets in the Peak Hour in 2000

	Express Bus	Trunk Bus	Total
Total	183	752	935
Factor for mentenance, reservation, etc =	1.2		
Total	220	902	1,123

Routes	Direction	Route Length (km)	Proposed Bus Operation Speed*) (km/h)		Average Dwelling time at Bus Stop (sec)		Operation Time between Terminals (hour)		Number of Allocated Buses /hour on shuttle operation	
			Express Bus	Trunk Bus	Express Bus	Trunk Bus	Express Bus	Trunk Bus	Express Bus	Trunk Bus
T0001	Inbound	28.8	30	20	15	7	0.96	1.44	28	58
	Outbound	28.8	30	20	13	5	0.96	1.44	28	58
T0003	Inbound	17.9	30	20	13	7	0.60	0.90	30	91
	Outbound	17.9	30	20	16	7	0.60	0.90	30	91
T0005	Inbound	16.0	30	20	20	9	0.53	0.80	33	100
	Outbound	16.0	30	20	15	7	0.53	0.80	33	100
T0006	Inbound	13.5	30	20	0	6	0.45	0.68	0	126
	Outbound	13.5	30	20	0	10	0.45	0.68	0	126

9.5.9. OPERATION SYSTEM IN 2005

(1) Demand and Trunk Busway Plan

Table 9.5-8 shows trunk busway plan according to passenger demand on each busway. In 2005, from among the eleven (11) busways, Av. Caracas, Autopista Norte, Calle 80 and Autopista Sur need the introduction of express bus system because passenger flows on these busways will exceed approximately 20,000 passengers/h/d.

As for Av. Suba as mentioned before, planning with 2-lane segregated busway on the existing road is not easy due to the difficulty of widening of road. Two trunk busways with 1-lane/dir are planned for the only trunk bus operation: on Av. Suba and a new busway from Av. Suba to Av. Caracas by way of Av. 127 to Autopista Norte.

On the other hand, since the busways on Calle 80 take the over passenger demands, it is difficult to operate on the trunk bus system proposed in 2005. As mentioned before, the express and trunk bus operations on the busway with 2-lanes/dir are proposed until completion of the Stage-2 in SITM's railway project to handle the over capacity of bus.

Table 9.5-8 Demand and Trunk Busway Plan in 2005

Busways	Bus Passengers/hour Total (Trunk+Ordinary)	Trunk Buses	Ratio of Trunk Buses	Type and No. of Lanes/dir.	Remarks
Cra 7a	21,000	21,000	100.0%	1-lane trunk busway/dir.	ROW: 30 m (difficulty of widening)
Car.10	29,000	19,000	65.5%	2-lane trunk busway/dir.	Difficulty of widening
Caracas in south	34,000	34,000	100.0%	Trunk and express busways (1-lane/dir. each)	ROW:40 m
Caracas in central	34,000	33,000	97.1%	Trunk and express busways (1-lane/dir. each)	ROW: 40 m
Autopista Norte	23,000	21,000	91.3%	Trunk and express busways (1-lane/dir. each)	ROW: 100 m
Av. Quito	23,000	20,000	87.0%	1-lane trunk busway/dir.	ROW: 60 m
Autopista Sur	29,000	27,000	93.1%	Trunk and express busways (1-lane/dir. each)	Possibility of widening
Calle 80	47,000	46,000	97.9%	Trunk and express busways (1-lane/dir. each)	Propose completing SITM's railway project until 2005
Cra.68	17,000	17,000	100.0%	1-lane trunk busway/dir.	ROW: 40 m
Av. Suba	20,000	13,000	65.0%	1-lane trunk busways/dir and 1-lane trunk busway on other busway route	Difficulty of widening
Calle 170	12,000	12,000	100.0%	1-lane trunk busway	Possibility of widening

(2) Scheduled Frequency and Headway

Table 9.5-9 summarizes the scheduled frequency and headway in the peak hour. The highest frequency in both the express and trunk bus operation is estimated on route No.T0051 that passes through Calle 80 to Av. Caracas. The figure is a frequency of approximately 80 /hour for the express bus and 25 for the trunk bus. Those headways of express and trunk buses are approximately 45 sec and 140 sec, respectively.

T0033 and T0049 where only trunk buses are operated are the busiest routes in the headway with 26 and 30 sec. T0033 is operated on Av. Caracas, while T0049 is on Calle 80.

The work utilization coefficient is also shown in Table 9.5-9. The routes with a work coefficient of 0.8 or over exceed approximately 70% of total. The routes with those higher figures are mainly inbound direction. On the other hand, the coefficients on routes in the outbound direction are low.

Table 9.5-9 Scheduled Frequency, Headway and Work Coefficient in the Peak Hour in 2005

Routes	Direction	Passengers on Board/hour		Scheduled Frequency /dir/hour			Headway (sec)			System Capacity (pax/h)			Ratio of Demand/ Capacity	Passenger-km	Space-km	a=Pax-km/Space-
		Maxmum passengers	Minimum passengers	Express Buses (200	Trunk Buses (100pax)	Total	Express Buses	Trunk Buses	Express and Trunk Buses	Express Buses	Trunk Buses	Route Total				
T0001	Inbound	456	8	-	4	4	-	900	900	-	400	400	1.140	4,869	7,440	0.654
T0002	Outbound	2,399	366	-	19	19	-	189	189	-	1,900	1,900	1.263	29,480	33,820	0.872
T0005	Inbound	417	5	-	4	4	-	900	900	-	400	400	1.043	1,152	6,200	0.186
T0006	Outbound	973	31	-	8	8	-	450	450	-	800	800	1.216	9,521	12,400	0.768
T0007	Inbound	2,342	177	-	19	19	-	189	189	-	1,900	1,900	1.233	20,348	32,680	0.623
T0008	Outbound	1,590	14	-	13	13	-	277	277	-	1,300	1,300	1.223	7,567	23,920	0.316
T0009	Inbound	3,973	64	-	31	31	-	116	116	-	3,100	3,100	1.282	25,295	55,490	0.456
T0010	Outbound	2,122	15	-	17	17	-	212	212	-	1,700	1,700	1.248	16,139	30,430	0.530
T0017	Inbound	13,002	1,263	49	16	65	73	225	55	9,800	1,600	11,400	1.141	189,114	336,300	0.562
T0018	Outbound	6,526	1,182	22	13	35	164	277	103	4,400	1,300	5,700	1.145	110,422	165,870	0.666
T0019	Inbound	857	266	-	7	7	-	514	514	-	700	700	1.224	8,292	10,080	0.823
T0020	Outbound	6,877	1,028	-	53	53	-	68	68	-	5,300	5,300	1.298	44,040	76,320	0.577
T0021	Inbound	11,082	1,425	-	86	86	-	42	42	-	8,600	8,600	1.289	195,241	281,220	0.694
T0022	Outbound	9,667	482	-	75	75	-	48	48	-	7,500	7,500	1.289	194,256	247,500	0.785
T0025	Inbound	2,460	612	-	19	19	-	189	189	-	1,900	1,900	1.295	11,508	12,160	0.946
T0026	Outbound	658	174	-	6	6	-	600	600	-	600	600	1.097	3,180	3,660	0.869
T0029	Inbound	7,227	1,265	-	56	56	-	64	64	-	5,600	5,600	1.291	26,367	31,360	0.841
T0030	Outbound	1,468	561	-	12	12	-	300	300	-	1,200	1,200	1.223	7,061	7,320	0.965
T0031	Inbound	16,974	2,866	56	33	89	64	109	40	11,200	3,300	14,500	1.171	195,679	261,000	0.750
T0032	Outbound	3,329	512	13	4	17	277	900	212	2,600	400	3,000	1.110	39,683	55,200	0.719
T0033	Inbound	15,453	1,342	-	119	119	-	30	30	-	11,900	11,900	1.299	171,795	248,710	0.691
T0034	Outbound	4,654	248	-	36	36	-	100	100	-	3,600	3,600	1.293	51,781	75,240	0.688
T0037	Inbound	5,027	105	-	39	39	-	92	92	-	3,900	3,900	1.289	55,212	65,520	0.843
T0038	Outbound	245	65	-	2	2	-	1,800	1,800	-	200	200	1.225	2,527	3,280	0.770
T0043	Inbound	3,028	780	-	24	24	-	150	150	-	2,400	2,400	1.262	48,158	49,440	0.974
T0044	Outbound	740	85	-	6	6	-	600	600	-	600	600	1.233	11,672	12,720	0.918
T0045	Inbound	5,394	2,475	-	42	42	-	86	86	-	4,200	4,200	1.284	83,365	84,840	0.983
T0046	Outbound	4,053	161	-	32	32	-	113	113	-	3,200	3,200	1.267	38,784	66,560	0.583
T0049	Inbound	17,903	435	-	138	138	-	26	26	-	13,800	13,800	1.297	206,308	259,440	0.795
T0050	Outbound	675	39	-	6	6	-	600	600	-	600	600	1.125	7,419	10,800	0.687
T0051	Inbound	21,504	583	80	25	105	45	144	34	16,000	2,500	18,500	1.162	209,371	314,500	0.666
T0052	Outbound	1,573	488	6	4	10	600	900	360	1,200	400	1,600	0.983	16,713	26,080	0.641
T0055	Inbound	10,710	920	-	83	83	-	43	43	-	8,300	8,300	1.290	106,428	156,870	0.678
T0056	Outbound	1,895	439	-	15	15	-	240	240	-	1,500	1,500	1.263	28,349	29,400	0.964
T0057	Inbound	11,023	3,383	-	85	85	-	42	42	-	8,500	8,500	1.297	151,927	158,950	0.956
T0058	Outbound	9,612	596	-	74	74	-	49	49	-	7,400	7,400	1.299	59,805	142,820	0.419
T0061	Inbound	14,145	5,205	47	28	75	77	129	48	9,400	2,800	12,200	1.159	163,412	208,620	0.783
T0062	Outbound	9,888	831	33	20	53	109	180	68	6,600	2,000	8,600	1.150	140,206	147,060	0.953
T0065	Inbound	4,709	181	-	37	37	-	97	97	-	3,700	3,700	1.273	46,053	76,590	0.601
T0066	Outbound	6,748	497	-	52	52	-	69	69	-	5,200	5,200	1.298	116,930	110,760	1.056
T0067	Inbound	5,263	953	-	41	41	-	88	88	-	4,100	4,100	1.284	51,663	59,450	0.869
T0068	Outbound	6,338	1,888	-	49	49	-	73	73	-	4,900	4,900	1.293	65,083	71,050	0.916
T0073	Inbound	11,492	2,163	-	89	89	-	40	40	-	8,900	8,900	1.291	109,533	133,500	0.820
T0074	Outbound	4,886	2,036	-	38	38	-	95	95	-	3,800	3,800	1.286	61,254	57,000	1.075
T0075	Inbound	3,886	7	-	30	30	-	120	120	-	3,000	3,000	1.295	36,066	50,700	0.711
T0076	Outbound	5,953	942	-	46	46	-	78	78	-	4,600	4,600	1.294	51,893	77,740	0.668
T0077	Inbound	2,115	275	7	17	24	514	212	150	1,610	1,700	3,310	0.639	18,768	45,016	0.417
T0078	Outbound	204	5	1	2	3	514	1,800	1,200	1,610	200	1,810	0.113	1,744	25,702	0.068
T0083	Inbound	5,361	246	-	42	42	-	86	86	-	4,200	4,200	1.276	65,779	103,320	0.637
T0084	Outbound	1,966	358	-	16	16	-	225	225	-	1,600	1,600	1.229	21,255	39,360	0.540
T0087	Inbound	6,471	34	-	50	50	-	72	72	-	5,000	5,000	1.294	71,940	146,000	0.493
T0088	Outbound	1,298	421	-	10	10	-	360	360	-	1,000	1,000	1.298	7,678	14,000	0.548
T0089	Inbound	5,768	78	-	45	45	-	80	80	-	4,500	4,500	1.282	72,425	121,950	0.594
T0090	Outbound	1,972	32	-	16	16	-	225	225	-	1,600	1,600	1.233	11,337	22,400	0.506
T0091	Inbound	3,375	475	12	7	19	300	514	189	2,400	700	3,100	1.089	31,803	36,580	0.869
T0092	Outbound	1,136	108	4	3	7	900	1,200	514	800	300	1,100	1.033	10,364	14,080	0.736
T0095	Inbound	10,164	169	-	79	79	-	46	46	-	7,900	7,900	1.287	108,697	194,340	0.559
T0096	Outbound	1,022	22	-	8	8	-	450	450	-	800	800	1.278	9,699	9,760	0.994
T0097	Inbound	9,778	373	-	76	76	-	47	47	-	7,600	7,600	1.287	140,809	186,200	0.756
T0098	Outbound	1,904	28	-	15	15	-	240	240	-	1,500	1,500	1.269	14,769	18,300	0.807
T0099	Inbound	11,442	4,916	-	89	89	-	40	40	-	8,900	8,900	1.286	253,026	265,220	0.954
T0100	Outbound	9,381	1,100	-	73	73	-	49	49	-	7,300	7,300	1.285	161,231	217,540	0.741
T0103	Inbound	8,151	785	-	63	63	-	57	57	-	6,300	6,300	1.294	112,246	119,070	0.943
T0104	Outbound	5,014	239	-	39	39	-	92	92	-	3,900	3,900	1.286	52,907	75,270	0.703

(3) Trunk Bus Flows on Busways

Table 9.5-10 summarizes the frequency and headway integrated on the trunk busways. Those figures show larger bus flows in both directions, which are mainly in the inbound direction. Av. Caracas is very busy in bus transport. The total numbers of buses are approximately 140 /hour for express and 410 for trunk buses in the peak hour. On Calle 80, the number of buses is 410 /hour (80 for express and 330 for trunk buses).

Table 9.5-10 Trunk Bus Flows on Busways in 2005

Busways	Frequency/hour			Headway (sec)		
	Express Bus	Trunk Bus	Total	Express Bus	Trunk Bus	Total
Cr7a	–	239	239	–	15	15
Cr10a	–	167	167	–	22	22
Quito	–	373	373	–	10	10
Auto. Sur	47	158	205	77	23	
Cra. 68	–	188	188	–	19	19
Calle 170	–	141	141	–	26	26
Av. Suba	–	63	63	–	57	57
Av. Caracas	142	410	552	25	9	
Boyaca	–	200	200	–	18	18
Calle 80	80	331	411	45	11	
Centenario	7	343	350	514	10	10
Americas	12	162	174	300	22	21
Auto. Norte	49	102	151	73	35	24

(4) Allocated Bus Fleets in Peak Hour

Table 9.5-11 shows the number of allocated bus fleets per hour in the peak hour which is estimated taking into account a round trip operation to return to a starting terminal. Considering the factor of maintenance and reservation of bus fleets, assuming on a factor of 1.2, the necessary number of articulated buses is approximately 380 in 2005, in contrast to 200 in 2000. The necessary number of trunk buses sharply increases, comparing to those in 2000. The figure is approximately 3,500 fleets, in contrast to 900 in 2000, making if possible to cut the ordinary bus routes by 46%. Articulated buses as well as express buses will newly need to be purchased. As for trunk buses, it is better to use the existing large sized buses as trunk buses. However, in order to increase a bus capacity, they need to remodel bus interior in the same manner as that in 2000.

Table 9.5-11 Numbers of Allocated Bus Fleets in the Peak Hour in 2005

		Express Bus	Trunk Bus	Total
	Total	320	2,886	3,206
Factor for maintenance, reservation, etc =		1.2		
	Total	384	3,463	3,848

Routes	Direction	Route	Proposed Bus Operation		Average Dwelling		Operation Time between		Number of Allocated	
			Express Bus	Trunk Bus	Express	Trunk	Express Bus	Trunk Bus	Express Bus	Trunk Bus
T0001	Inbound	18.6	30	20	0	4	0.62	0.93	0	17
T0002	Outbound	17.8	30	20	0	7	0.59	0.89	0	17
T0005	Inbound	15.5	30	20	0	9	0.52	0.78	0	6
T0006	Outbound	15.5	30	20	0	4	0.52	0.78	0	6
T0007	Inbound	17.2	30	20	0	9	0.57	0.86	0	16
T0008	Outbound	18.4	30	20	0	11	0.61	0.92	0	16
T0009	Inbound	17.9	30	20	0	9	0.60	0.90	0	28
T0010	Outbound	17.9	30	20	0	13	0.60	0.90	0	28
T0017	Inbound	29.5	30	20	14	7	0.98	1.48	48	16
T0018	Outbound	29.1	30	20	21	10	0.97	1.46	48	16
T0019	Inbound	14.4	30	20	0	12	0.48	0.72	0	38
T0020	Outbound	14.4	30	20	0	12	0.48	0.72	0	38
T0021	Inbound	32.7	30	20	0	7	1.09	1.64	0	86
T0022	Outbound	33.0	30	20	0	9	1.10	1.65	0	86
T0025	Inbound	6.4	30	20	0	20	0.21	0.32	0	3
T0026	Outbound	6.1	30	20	0	19	0.20	0.31	0	3
T0029	Inbound	5.6	30	20	0	24	0.19	0.28	0	3
T0030	Outbound	6.1	30	20	0	25	0.20	0.31	0	3
T0031	Inbound	18.0	30	20	26	12	0.60	0.90	34	30
T0032	Outbound	18.4	30	20	27	12	0.61	0.92	34	30
T0033	Inbound	20.9	30	20	0	12	0.70	1.05	0	119
T0034	Outbound	20.9	30	20	0	18	0.70	1.05	0	119
T0037	Inbound	16.8	30	20	0	7	0.56	0.84	0	33
T0038	Outbound	16.4	30	20	0	8	0.55	0.82	0	33
T0043	Inbound	20.6	30	20	0	7	0.69	1.03	0	24
T0044	Outbound	21.2	30	20	0	10	0.71	1.06	0	24
T0045	Inbound	20.2	30	20	0	10	0.67	1.01	0	42
T0046	Outbound	20.8	30	20	0	11	0.69	1.04	0	42
T0049	Inbound	18.8	30	20	0	9	0.63	0.94	0	130
T0050	Outbound	18.0	30	20	0	9	0.60	0.90	0	130
T0051	Inbound	17.0	30	20	22	10	0.57	0.85	45	21
T0052	Outbound	16.3	30	20	24	10	0.54	0.82	45	21
T0055	Inbound	18.9	30	20	0	11	0.63	0.95	0	78
T0056	Outbound	19.6	30	20	0	13	0.65	0.98	0	78
T0057	Inbound	18.7	30	20	0	13	0.62	0.94	0	79
T0058	Outbound	19.3	30	20	0	12	0.64	0.97	0	79
T0061	Inbound	17.1	30	20	23	11	0.57	0.86	27	24
T0062	Outbound	17.1	30	20	26	12	0.57	0.86	27	24
T0065	Inbound	20.7	30	20	0	11	0.69	1.04	0	52
T0066	Outbound	21.3	30	20	0	14	0.71	1.07	0	52
T0067	Inbound	14.5	30	20	0	12	0.48	0.73	0	36
T0068	Outbound	14.5	30	20	0	12	0.48	0.73	0	36
T0073	Inbound	15.0	30	20	0	9	0.50	0.75	0	67
T0074	Outbound	15.0	30	20	0	13	0.50	0.75	0	67
T0075	Inbound	16.9	30	20	0	16	0.56	0.85	0	39
T0076	Outbound	16.9	30	20	0	14	0.56	0.85	0	39
T0077	Inbound	13.6	30	20	20	2	0.45	0.68	3	12
T0078	Outbound	14.2	30	20	19	3	0.47	0.71	3	12
T0083	Inbound	24.6	30	20	0	12	0.82	1.23	0	42
T0084	Outbound	24.6	30	20	0	16	0.82	1.23	0	42
T0087	Inbound	29.2	30	20	0	10	0.97	1.46	0	50
T0088	Outbound	14.0	30	20	0	16	0.47	0.70	0	50
T0089	Inbound	27.1	30	20	0	12	0.90	1.36	0	45
T0090	Outbound	14.0	30	20	0	25	0.47	0.70	0	45
T0091	Inbound	11.8	30	20	36	18	0.39	0.59	3	4
T0092	Outbound	12.8	30	20	39	13	0.43	0.64	3	4
T0095	Inbound	24.6	30	20	0	11	0.82	1.23	0	79
T0096	Outbound	12.2	30	20	0	27	0.41	0.61	0	79
T0097	Inbound	24.5	30	20	0	15	0.82	1.23	0	76
T0098	Outbound	12.2	30	20	0	26	0.41	0.61	0	76
T0099	Inbound	29.8	30	20	0	14	0.99	1.49	0	89
T0100	Outbound	29.8	30	20	0	16	0.99	1.49	0	89
T0103	Inbound	18.9	30	20	0	16	0.63	0.95	0	60
T0104	Outbound	19.3	30	20	0	16	0.64	0.97	0	60

9.5.10. SHARE OF EXPRESS BUS AND TRUNK BUS

In Bogota, future public mass transport system will be composed of the trunk bus, express bus, ordinary bus and SITM railway, in contrast to only service of ordinary bus at present. In this section, the future share of public transport system is analyzed.

Figure 9.5-6 shows the shares of public transport modes in terms of passenger-km in 2000. The highest share is the ordinary bus (81% of the total), followed by trunk bus (10%) and express bus (9%). In 2000, only three (3) trunk busway with 4 trunk and 3 express bus routes will be operated, while 70% of current bus routes remain.

Figure 9.5-7 also shows the shares of public transport modes in 2005 in the same manner. In 2005, approximately 45% of current bus routes will be cut and major public transport will be replaced with the trunk bus system. This bus system will be operated on the 11 trunk busways with 32 trunk bus routes and 6 express bus routes. Therefore, the share of trunk bus accounts for approximately 50% of the total. The ordinary bus share reduces by 30%, in contrast to 81% in 2000.

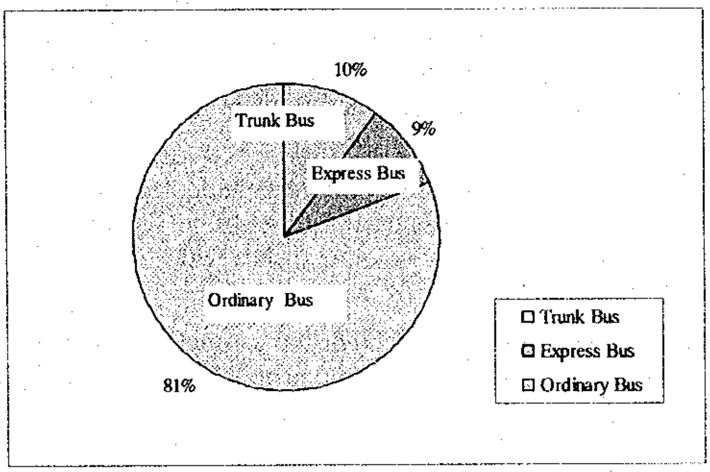


Figure 9.5-6 Shares of Passenger-km by Mass Public Transport Modes in 2000

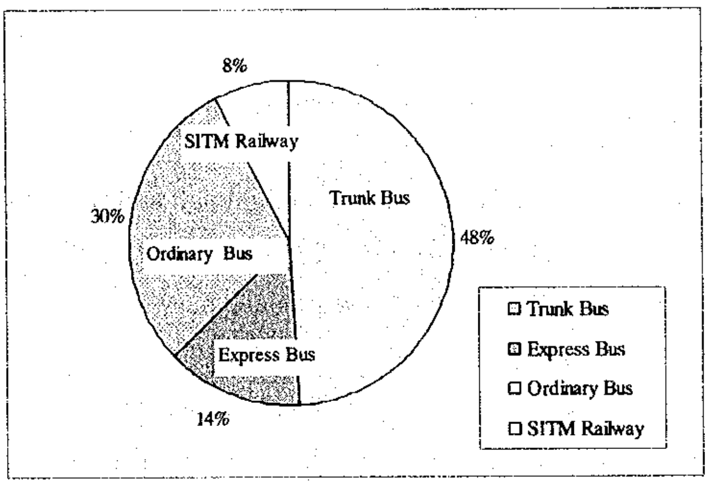


Figure 9.5-7 Shares of Passenger-km by Mass Public Transport Modes in 2005

9.6. TRAFFIC FLOW CONDITIONS ON AV. CARACAS ESTIMATED BY TRAFFIC SIMULATION

9.6.1. GENERAL

In 2005, on Av. Caracas two types of bus service will be in the trunk bus system: trunk and express bus services. The express buses run on the fully segregated busways on the elevated road and trunk buses are operated on fully segregated busways with signalized intersections on at-grade roads. As for bus operation system, the service frequencies with 140 /hour for express and 410 for trunk buses in the peak hour which are equivalent to a headways of 25 and 9 sec, respectively will be needed on Av. Caracas from the demand analysis in previous Section. Since on at-grade road, trunk bus flow rate on trunk busway is very heavy, it is necessary to verify the saturation degree on the proposed bus operation system taking into account dwelling time at bus stops and behavior at signalized intersections.

Therefore, in order to predict the congested degree on Av. Caracas on the proposed bus trunk system, the bus operation performance is simulated on a computer by means of a simulation model. By the model, it is possible to predict the effect of operation performance, as expressed in terms of measures of effectiveness, which include average bus speed, vehicle stops, delays, etc.

The TRAF models, which involve the software supported by the Federal Highway Administration in U.S.A. (FHWA), was used in the Study. TRAF is an integrated software system that consists of NETSIM and others. NETSIM is a microscopic stochastic simulation model of urban traffic.

In this Section, the determination as to whether the estimated service frequency for express and trunk buses exceeds the line-capacity of the proposed busway facility, is validated with the TRAF model.

9.6.2. PROCEDURE OF ANALYSIS

(1) Procedure

In order to simulate traffic characteristics on Av. Caracas, the road segment on Av. Caracas between Calle 63 and calle 45 was chosen as a study area. The procedure of analysis is as follows:

1) To collect present traffic data on Av. Caracas
   - Bus flow volumes
   - Private vehicle traffic volume for straight, left and right-turn movement
2) To collect road inventory data on Av. Caracas between Calle 63 and calle 45
   - Number of lanes: 2-lane/ dir with segregated busway
   - Location of bus stops
   - Number of bus bays: 2-bus bays with on-line bus bay
   - Traffic signals: locations, cycle length, and off-set time
3) To set parameters for simulation model
   - Bus fleet size
   - Dwelling time at bus stops

- Operation headway
- Driver characteristics

4) To calibrate the present traffic conditions
5) To simulate traffic conditions for buses and private vehicles in Without case and to disclose the limitation of the current bus system
6) To simulate traffic conditions for trunk buses and private vehicles in With case and to predict traffic conditions on elevated busway and at-grade road with signalized intersections

Figure 9.6-1 summarizes the estimation flow for traffic conditions on Av. Caracas with traffic simulation.

(2) Output Data

The system operation performance is expressed in terms of measures of effectiveness, which include bus flows, service frequency, average vehicle speed, delay time at intersections derived from the simulation model.

Estimation Flow for Traffic Conditions on Av. Caracas by Traffic Simulation

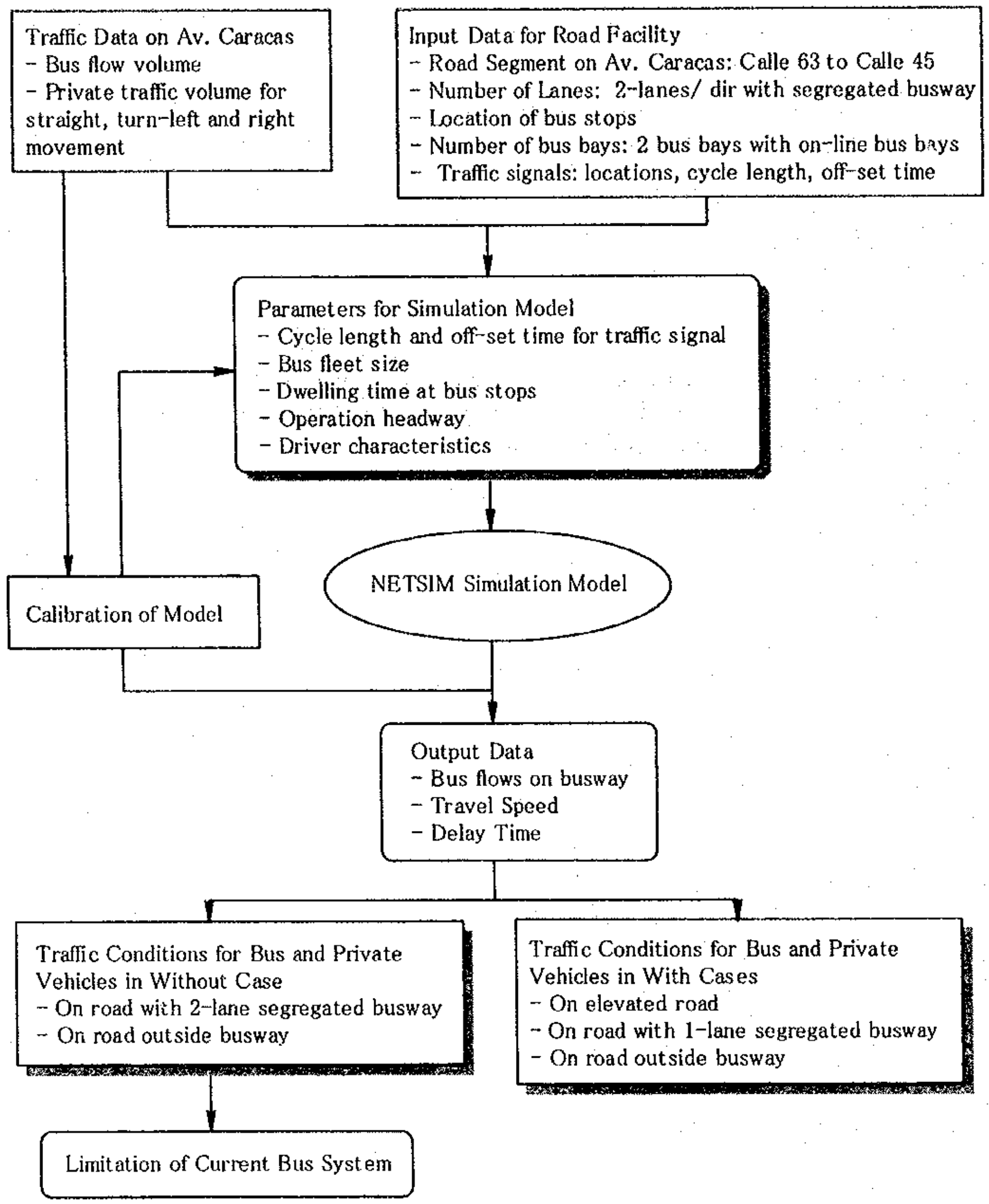


Figure 9.6-1 Estimation Flow by Traffic Simulation

9.6.3. VALIDATION OF PRESENT TRAFFIC CONDITIONS ON AV. CARACAS

Av. Caracas is served with 2-lane/direction fully segregated busway at present. The busway is located on the median side. The bus stop facility has 4-sets of 2-bus bays with on-line bus bay on outside lane. The bus stops are located only on the outside bus lane in spite of 2-lane busway. According to the count data in 1998 on Av. Caracas, the number of bus flows in the peak hour varies from 500 to 600 buses on busway. If every bus running on the median-side bus lane approaches the bus bays by weaving maneuvers, it is difficult to operate these bus volumes. Since at present, bus passengers board buses across the bus lane in the side of a sidewalk, which run on median-side bus lane, it appears as though buses are just operated with bus bays on each bus lane.

(1) Traffic Conditions

The present traffic conditions on Av. Caracas are validated with the simulation model in which the model parameters are optimized. Figure 9.6-2 shows the relationship between bus flow rate and operation frequency in segment-1 with bus stop and segment-2 without bus stop. As can be seen, in both segments, the higher the frequencies are, the heavier the bus flow rates are and then, the bus flow rates gradually decrease after the frequencies reach at some high values.

In the model, vehicles move according to car-following logic, response to traffic control devices, and response to other demands. Buses, however, must service at bus stop; therefore, their movements differ from those of private vehicles. Congestion can result in queues that extend throughout the length of a link and block the upstream intersection, thus impeding traffic flow.

Since in the model, each vehicle's behavior can be simulated in a manner reflecting real-world processes, no matter how high the service frequency is, bus flow rates are decrease due to unstable flow conditions. As can be seen in Figure 9.6-2, the highest number of bus flow rates is approximately 600 in peak hour. This figure is similar to the present traffic volume on Av. Caracas. According to the analysis with the model, the bus volume at the present on Av. Caracas reaches critical density. The current bus system is close to its limits

(2) Delay Time

Figure 9.6-3 shows relationship between total delay time and frequency in both segments. In segment-1 with bus stop, the delay is due to dwell time at bus stop and waiting time at traffic signals. When bus flow rate exceeds 500, total delay time increases due to increase of waiting time at intersections and conflicts near bus stops. Total delay time in segment-2 is smaller than that in segment-1 because of no bus stops along the routes. In this section, when exceeding frequency of 300 or over, traffic congestion occurs.

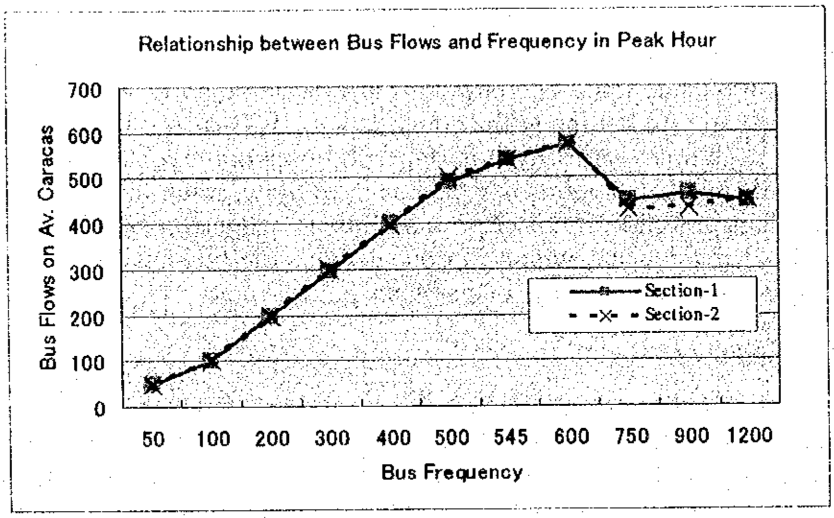


Figure 9.6-2 Relationship between Bus Flow Rate and Frequency

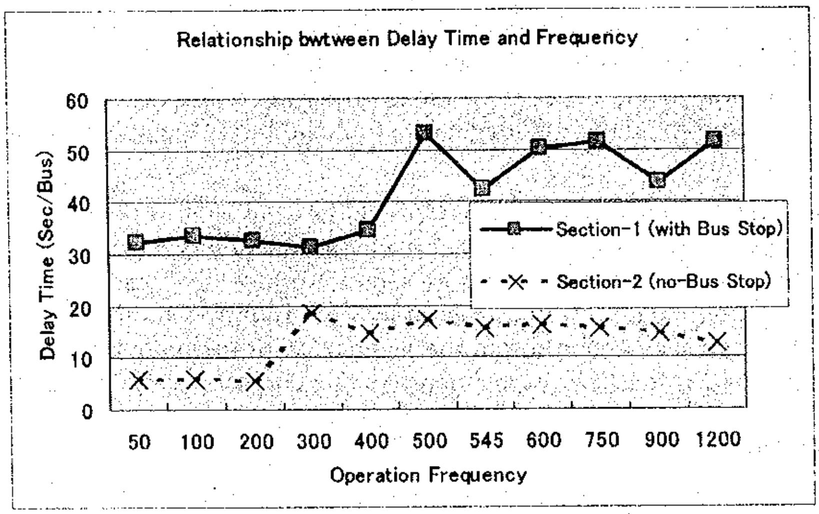


Figure 9.6-3 Relationship between Total Delay Time and Frequency

9.6.4. TRAFFIC CONDITIONS IN WITHOUT CASE

In without project case on Av. Caracas in 2000 and 2005, the estimated increase ratios of bus traffic volume are 1.05 and 1.10, respectively according to the demand analysis. Therefore, the volumes in 2000 and 2005 are forecasted at approximately 630 and 660, respectively. According to Figure 9.6-2 those figures will exceed the present bus flow capacity on Av. Caracas. Therefore, it will be necessary to introduce the proposed trunk bus system (both the busway and operation system).

9.6.5. TRAFFIC CONDITIONS ON TRUNK BUS SYSTEM IN 2005

(1) On Elevated Busway for Express Buses

The proposed express bus system is as follows: the express buses will be operated on the elevated busway which will provide 1-lane segregated bus lane/ dir with off-line bus bays which have 2 booths. The articulated buses run on the busway without traffic signals.

Figure 9.6-4 shows the relationship between express bus flow rate and frequency on the elevated busway simulated by the model. The highest number of bus flow rates is approximately 300 in the peak hour. This figure indicates the maximum bus flow rates in the system. In 2005, the estimated number of express bus flow rates on the elevated busway is approximately 150 in the peak hour. The capacity of the elevated busway is sufficient for the bus flow rates for a period of a decade beyond 2005.

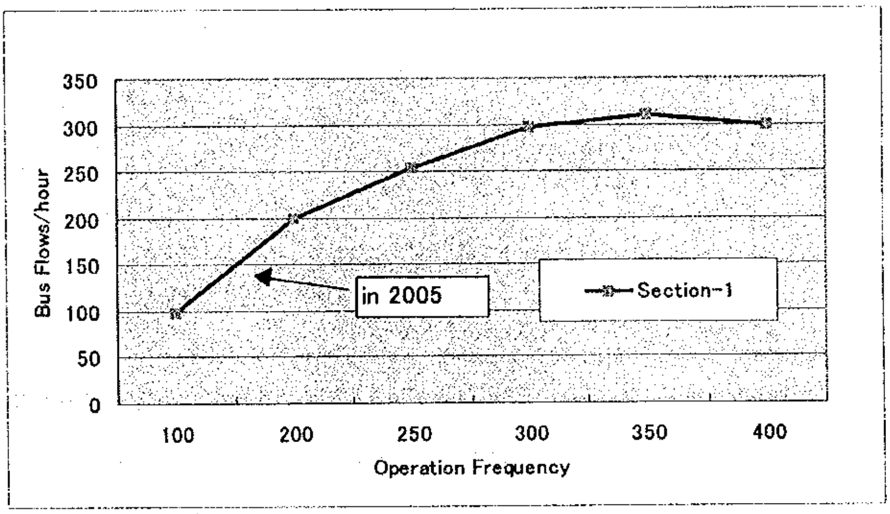


Figure 9.6-4 Relationship between Express Bus Flow Rate and Frequency on Elevated Busway

(2) On Trunk Busway for Trunk Buses

The proposed trunk bus system is as follows: the trunk buses are operated on the fully at-grade segregated busway which provides 1-lane segregated bus lane/ dir with on-line bus bays which have 2 booths. The trunk buses run on the busway with traffic signals at intersections.

Figure 9.6-5 shows the relationship between trunk bus flow rate and frequency on the trunk busway according to number of bus booths. The highest number of bus flow rates is approximately 350 in the peak hour with 5-6 bus booths. The current bus booths on Av. Caracas are 8 booths. On 4 or less bus booths, the maximum number of bus flow rates is approximately 300.

In 2005, the estimated number of trunk bus flows on Av. Caracas is approximately 400 in the peak hour. This figure will exceed the proposed flow capacity on trunk busway.

In order to reduce the number of trunk bus flow rates in the peak hour, it is necessary to use the articulated buses as a trunk bus. In the simulation, the bus flow rate is simulated by using a variable in terms of the composition ratios of articulated buses to total trunk buses. Its ratios are set at 20%, 15% and 10%.

Figure 9.6-6 shows the relationship bus flow rate and frequency according to composition ratios of articulated buses. The bus flow rates relate with the composition ratio of articulated buses. The higher the composition ratios are, the lower the bus flow rates are.

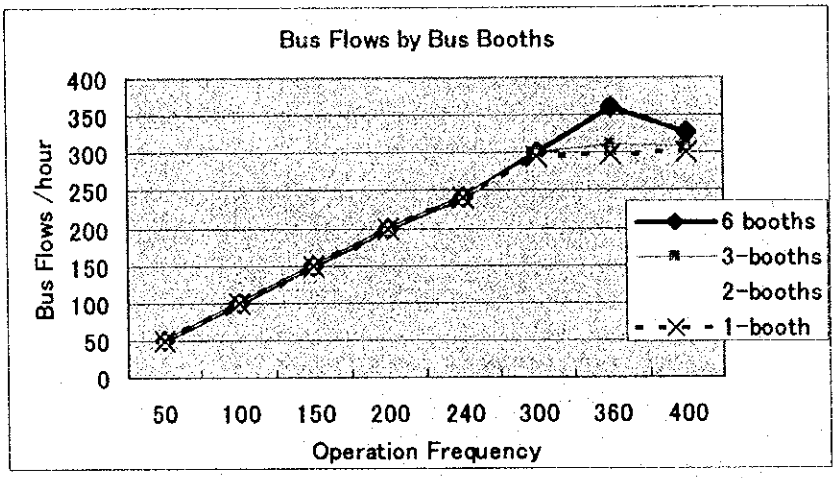


Figure 9.6-5 Relationship between Trunk Bus Flow Rate and Frequency by Bus Booth

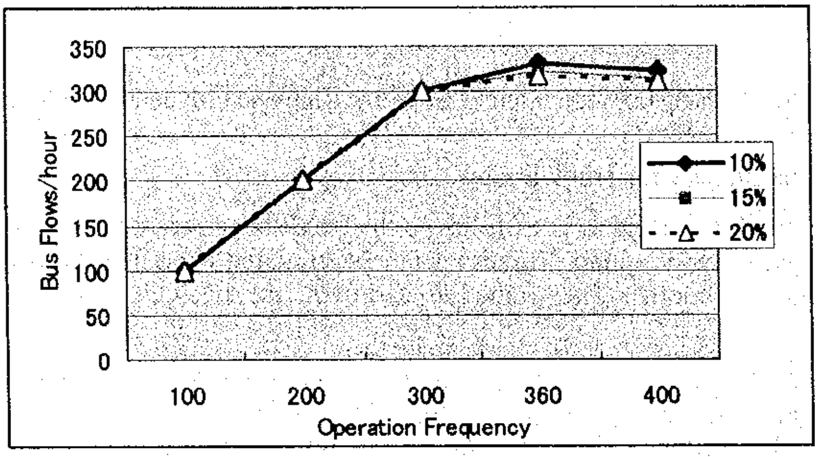


Figure 9.6-6 Bus Flow Rate by Composition of Articulated Buses

Table 9.6-1 shows the maximum number of bus flow rates by the composition ratio of articulated buses referred to Figure 9.6-6. The maximum figures are 330 buses/hour in case of a composition of 10%. In consideration of bus passenger capacity by trunk and articulated buses, the maximum number of passengers transported on the trunk busway is 37,800 per hour at an articulated bus ratio of 20%.

In the demand analysis in the previous section, since in 2005 bus passengers are estimated at 34,000, it will be necessary to mix the trunk buses with articulated buses, 10 – 15% of the total. The trunk buses on the fully at-grade segregated busway become possible to operate under this procedure.

Table 9.6-1 Number of Buses and Passengers According to Articulated Bus Composition

Composition of Articulated Buses (%)	No. of Buses	Passengers	Maximum passengers on Caracas
10	330	36,300	34,000
15	320	36,800	
20	315	37,800	

9.7. REARRANGEMENT OF CURRENT BUS ROUTES

9.7.1. CUTTING CURRENT BUS ROUTES

Seventy percent (70%) in 2000 and 55% in 2005 of the total ordinary bus routes on the current bus system will remain, respectively. The ordinary buses will be operated on the current bus routes. In case where the current bus routes are on roads with the trunk busways, the ordinary buses will be operated on the outside of the segregated busways or of the trunk bus exclusive lane, together with private vehicles. Therefore, since the priority for operation of ordinary buses with a privilege such as travelling on the busway is not given, the bus commercial speed will be reduced according to the increase of traffic volume.

The ordinary buses, however, play an important role in the public transport. In 2000, only 4 trunk bus routes will be operated on the three busways and almost all the passengers will use the ordinary buses. In 2005, in case of absence of the ordinary bus service, heavy passenger demand will be beyond the line capacity of trunk busway. Therefore, in order to reduce the load of passenger demand on the busways, it is indispensable to supplement ordinary bus routes not to overlap with trunk bus routes.

Approximately 30% of the total ordinary bus routes that overlap with the trunk busways will be cut in 2000 in order to be diverted to the trunk buses. Consequently, in 2005, approximately 45% of the ordinary routes will be cut.

The criteria of discontinued ordinary bus routes is as follows:

1) In 2000, the ordinary bus routes where a length of route overlapping with busways on Av. Caracas and Calle 80 is 2.5 km or more, will be cut.

2) In 2005, the ordinary routes with an overlapped length of 4.5km or more with Av. Caracas and 9.0km or more with other busways will also be cut. The criterion of overlapped length on Av. Caracas is shorter than that on others, because many bus routes concentrate on Av. Caracas. It is necessary to cut many ordinary bus routes overlapping with Av. Caracas.

It is necessary to rearrange those discontinued ordinary bus routes. On the other hand, since the ratio of remained ordinary route overlapping with the trunk busways is low, the ordinary buses are maintained as a supplementary service to trunk buses.

9.7.2. REARRANGEMENT OF DISCONTINUED ORDINARY BUS ROUTES

Several discontinued ordinary bus routes need rearrangement, as related with those route configurations. The procedures for rearrangement of routes are as follows:

1) A long route is divided into two or more routes.

2) A winding route is cut or is divided into two or more routes.

3) Ordinary bus routes should connect to the trunk bus routes or SITM's main railway stations, since ordinary buses function as a supplementary service of trunk buses.

4) A section of ordinary bus route overlapped with trunk busway should be replaced by planned a route to cross the trunk busways.

9.8. SUMMARY OF TRUNK BUS OPERATION SYSTEM

Table 9.8-1 briefly summarizes the outline of trunk bus system in 2000 and 2005, respectively, which includes routes, bus facilities, and bus system to be applied on busway. Table 9.8-2 and Table 9.8-3 also summarize the bus operation system to be applied on busway.

Table 9.8-1 Summary of Bus Operation System

Policy Items	Contents of Bus System	Remarks
(1) Bus Operation System in 2000		
1) Busways on Trunk bus system	4 busways on Norte, Caracas, Calle 80 and Corredor Ferreo del Sur	
2) Number of trunk bus routes	4 trunk bus routes	
3) Types of bus operation	Express buses, trunk buses, and ordinary buses	
4) Discontinued number of ordinary bus routes	Target: 30% of the total ordinary bus routes	Taking into account phase out of old fleet
(2) Bus Operation System in 2005		
1) Busways on Trunk bus system	11 busways on major roads	
2) Number of trunk bus routes	32 trunk bus routes	
3) Types of bus operation	Express buses, trunk buses, and ordinary buses	
4) Discontinued number of ordinary bus routes	Target: 45% of the total ordinary bus routes	Taking into account phase out of old fleet
(3) Bus capacity	Express buses (200 passengers), trunk buses (100 passengers), and ordinary buses (20-40 passengers)	
(4) Busway Capacity		
1) Scheduled line cpacity	Express bus: 16,000 pax/lane/hour/dir.	A headway of 45 sec.
	Trunk bus: 8,000 pax/lane/hour/dir	
2) System criteria of trunk busways	12,000- 20,000 pax/hour/dir. for introduction of express bus system	
	12,000 or less for trunk bus system on 2 lane busway	
	6,000 or less for trunk bus system on 1 lane busway	
3) Planning policy for busways with 30,000 or more	* To propose additional trunk busways	
	* To propose urgent railway plan	
(5) Bus Facility		
1) Bus stop spacing	A distance of 1-1.5 km for express buses	
	A distance of 500-600 m for trunk buses	
2) Bus facilities	Bus stop	
	Bus U-turn facility	in 2000
	Suburban bus terminals near peripherical areas of Bogota	
	Central bus terminal	in 2005

Table 9.8-2 Bus System to be applied by Each Busway in 2000

Busways	Trunk Bus Passengers/hour on Busway	Plan and No. of Lanes/dir.	Remarks
Autopista Notre	11,000	1-lane trunk busway/dir and 1-lane express busway/dir	Existing right of way: 100m
Caracas in south	20,000	1-lane trunk busway/dir and 1-lane express busway/dir	ROW: 40 m
Caracas in central	30,000	1-lane trunk busway/dir and 1-lane express busway/dir	ROW: 40 m
Calle 80	24,000	1-lane trunk busway, and 1-lane express bus	Under construction of trunk busways with 2-lane /dir.
Ferreo de Sur	19,000	2-lane trunk buway	

Table 9.8-3 Bus System to be applied by Each Busway in 2005

Busways	Bus Passengers/hour			Plan and No. of Lanes/dir.	Remarks
	Total (Trunk+ Ordinary Buses)	Trunk Buses	Ratio of Trunk Buses		
Cra 7a	21,000	21,000	100.0%	1-lane trunk busway/dir.	ROW: 30 m (difficulty of widening)
Car.10	29,000	19,000	65.5%	2-lane trunk busway/dir.	Difficulty of widening
Caracas in south	34,000	34,000	100.0%	Trunk and express busways (1-lane/dir. each)	ROW:40 m
Caracas in central	34,000	33,000	97.1%	Trunk and express busways (1-lane/dir. each)	ROW: 40 m
Autopista Norte	23,000	21,000	91.3%	Trunk and express busways (1-lane/dir. each)	ROW: 100 m
Av. Quito	23,000	20,000	87.0%	1-lane trunk busway/dir.	ROW: 60 m
Autopista Sur	29,000	27,000	93.1%	Trunk and express busways (1-lane/dir. each)	Possibility of widening
Calle 80	47,000	46,000	97.9%	Trunk and express busways (1-lane/dir. each)	Propose completing SITM's railway project until 2005
Cra.68	17,000	17,000	100.0%	1-lane trunk busway/dir.	ROW: 40 m
Av. Suba	20,000	13,000	65.0%	1-lane trunk busways/dir and 1-lane trunk busway on other busway route	Difficulty of widening
Calle 170	12,000	12,000	100.0%	1-lane trunk busway	Possibility of widening

PART C

PLANNING OF INNER RING EXPRESSWAY

CHAPTER 10
Planning Conditions of Inner Ring Expressway Project

PART-C PLANNING OF INNER RING EXPRESSWAY

10. PLANNING CONDITIONS OF INNER RING EXPRESSWAY PROJECT

10.1. PLANNING ENVIRONMENT

10.1.1. BACKGROUND OF THE INNER RING EXPRESSWAY PROJECT

The Master Plan for Urban Transport of Santa Fe de Bogota in the Republic of Colombia was conducted by Japan International Cooperation Agency (JICA) over a period of one and one half years from July 1995 to December 1996. In the Master Plan, three (3) different transport sector development plans were recommended such as traffic management development plan, road network development plan, and public transport network development plan for mitigation of traffic congestion within the city of Bogota.

Among the three (3) different categories of road sector project of the road network development plan in the Master Plan, certain projects were recommended such as the ten (10) existing road improvement projects, seventeen (17) new road construction projects, and three (3) urban expressway development projects consisting of Inner Ring Expressway, Second Ring Expressway, and four (4) Radial Urban Expressways.

Taking into account the existing and future traffic conditions of central area in Bogota city, the public transport conditions in the city of Bogota, the transport facilities conditions in Bogota, and the implementation schedule of proposed projects in the Master Plan, the Inner Ring Expressway (IRE) project was selected for the conduct of Feasibility Study for mitigation of the traffic congestion within the area which is covered by central business area in Bogota. This is considered an urgent transport improvement plan, and is referred to as "the Feasibility Study of the Inner Ring Expressway".

The Feasibility Study of IRE will be conducted based on the various development plans prepared by IDU, STT, DAPD, and related authorities of Bogota. It will be carried out with mutual cooperation between the JICA Study Team and the Colombian counterpart personnel and officers of related agencies of Bogota City.

10.1.2. DEFINITION OF INNER RING URBAN EXPRESSWAY

As previously mentioned, the Inner Ring Expressway, Second Ring Expressway, and four (4) Radial Expressways development plans were recommended in the Transport Master Plan in Bogota as the future Urban Expressway network configuration in Bogota. The function and characteristics of the Inner Ring Expressway is to mitigation of the traffic congestion at the central area of Bogota at the urgently, and its of the Second Ring Expressway are to mitigate the traffic congestion at the surrounding area of central area in Bogota, and also to maintain the traffic diversion from/to Radial Urban Expressway. The other hand, the function and characteristics of the four (4) Radial Urban Expressways is the urgent mitigation of the traffic congestion on the existing radial roads such as Autopista Norte, Sur, Medellin and El Dorado, and also to maintain the traffic from/to the surrounding cities of Bogota such as Soacha, Mosqura, Cota and so on (Bogota Metropolitan Area).

According to the recommendation of the Transport Master Plan, the implementation schedule of the Inner Ring Expressway, Second Ring Expressway, and the four (4) Radial Expressway are shown in Table 10.1-1.

Table 10.1-1 Implementation Schedule of Urban Expressway based on Transport Master Plan

Road Name	Design Period	Land Preparation	Construction Period	Operation Year
Inner Ring	1998-1999	2000	2001-2005	2006
Second Ring	2006	2007	2008-2011	2012
Radial Expressway	2014	2015	2016-2020	2021

10.1.3. Study Area of Inner Ring Expressway

Considering the functions and characteristics of the Inner Ring Expressway and balance of Urban Expressway network configuration, the study area for route location of the Inner Ring Expressway should cover the central urban district (CBD) in Bogota, which is covered by Avenida 7, Calle 100, Avenida Quito, and Calle 6. The route location of the Inner Ring Expressway will be conducted within this area.

10.1.4. Planning Target Year

In the Transport Master Plan in Bogota, the Inner Ring Expressway was recommended as an urgent undertaking to mitigate the traffic congestion within the central area of Bogota City. Based on the Transport Master Plan, the target year of the Inner Ring Expressway is identified in the year 2005.

10.1.5. Major Study Items

The Study is to conduct the feasibility study for the Inner Ring Expressway recommended by the Transport Master Plan in Bogota that was conducted by JICA Study in the period from July 1995 to December 1996. The major study items for the feasibility study of the Inner Ring Expressway are as follows:

1) Review and analysis of data and information
2) Identification of planning policy and strategy
3) To conduct various field surveys (topographic, soil investigation, inventory)
4) To conduct supplementary traffic survey
5) Projection of future traffic volume
6) Initial environmental examination
7) Preparation and evaluation of alternative routes
8) Preliminary engineering (topographic maps at scale of 1: 5,000)
9) Environmental impact assessment
10) Project cost estimation
11) Preparation of implementation schedule and financial resources
12) Project evaluation (economical, financial, technical, environmental, social)
13) Recommendations

10.2. TRAFFIC CHARACTERISTICS IN BOGOTA

The traffic characteristics in the City of Bogota is examined based on the results of person trip survey in the Transport Master Plan of Bogota which was prepared by JICA in 1995 to 1996. The detailed traffic characteristics in the city of Bogota refer to the Report of the Transport Master Plan.

10.2.1. TRAFFIC FLOW CHARACTERISTICS

As shown in Figure 10.2-1, the total number of person trip of Bogota per day in year 1995 and in year 2020 were estimated as 11,550,000, and 19,342,000 person trips respectively. From the Figure 10.2-1, the following traffic characteristics in the city of Bogota can be recognized.

(1) In the Year 1995

1) 95 % of total number of person trips, that is, 10,960,000 person trips per day were maintained within the city of Bogota.
2) 5 % of total number of person trips, that is, 579,000 person trips per day were from/to outside Bogota City.
3) Only 0.13% of total number person trips, that is, 15,000 person trips per day were by-passing the city of Bogota.
4) From the above-mentioned numbers, the person trip movements in the City of Bogota are basically within Bogota.

(2) In the Year 2020

1) 91 % of the total number of person trips, that is, 17,592,000 person trips per day will be operated within the City of Bogota
2) The person trip movements between Bogota city and outside Bogota city in year 2020 will be increased about three (3) times their level in year 1995. This means, the development pressure in the surrounding cities of Bogota will be increased rapidly.
3) By-passing traffic of the city of Bogota in year 2020 will still be very small. Only 0.35 % of total person trips per day, that is, 63,000 person trips per day will be diverted inside the city of Bogota.

10.2.2. TRAFFIC CHARACTERISTICS OF EACH AREA IN BOGOTA

From the viewpoint of the traffic and transport conditions, and land use, construction and social conditions in Bogota city, the urbanized area of Bogota city can be divided into three different categories: Area-A, Area-B, and Area-C.

Area-A is covered by Avenida 7a, Avenida Quito, and Primero de Mayo, and Area-B is covered Avenida Quito, Avenida 68, and Autopista Sur. Area -C is covered by Autopista Norte, Avenida Boyaca, Avenida 68, and Autopista Sur, see Figure 10.2-2. The traffic characteristics of each Area are presented in Table 10.2-1.

From the Table 10.2-1, the following observation regarding traffic conditions in each Area can be concluded.

1) From the viewpoint of road ratio for trunk road network, the road ratio of Area-A is about 4.9 km/km2 where as in other Areas it is about 2.2 km/km2. These figures indicate comparatively sufficient road length.

2) In spite of maintaining sufficient road length, the traffic congestion degree of each Area is very heavy. The average congestion degree of Area-A is about 0.9. This means that almost all the trunk roads in Area-A have reached their traffic capacity. Therefore, some traffic congestion mitigation plan should be implemented as soon as possible.

3) The average congestion degree of Area-B and C also indicate that the traffic capacity within these Areas will soon be reached. Therefore, some mitigation plan for traffic congestion should be implemented soon.

4) It is very difficult to implement the widening of existing roads of Area-A, because, there are many buildings along the existing roads.

5) When mitigation measure for traffic congestion in the Area-A are prepared, a combination plan such as Urban Expressway Project, Public Transport Project, Traffic Management Project, and Traffic Demand Management Project (TDM) should be considered.

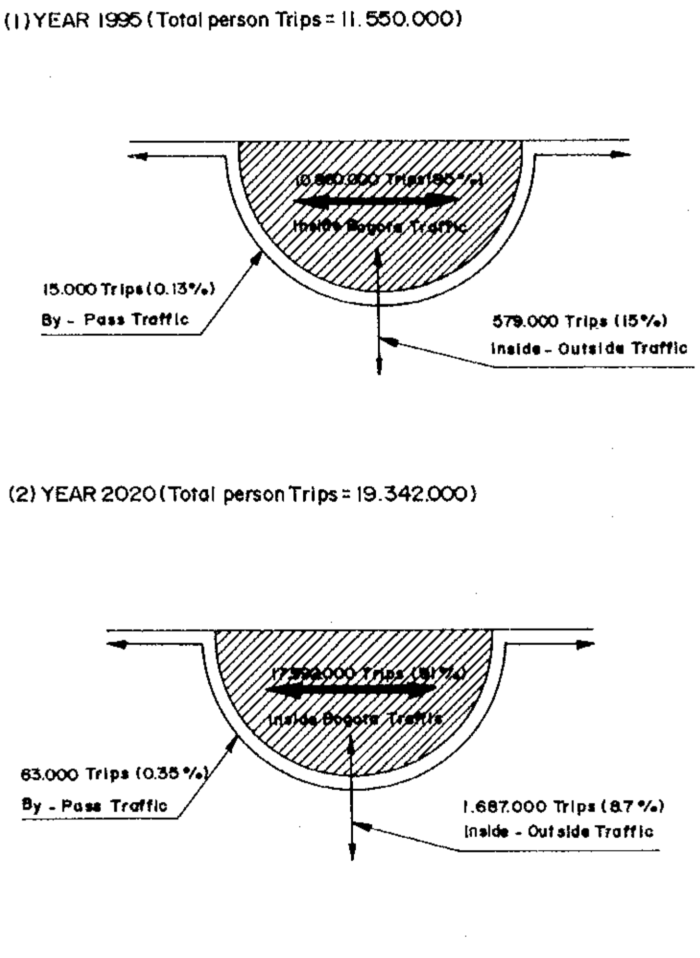
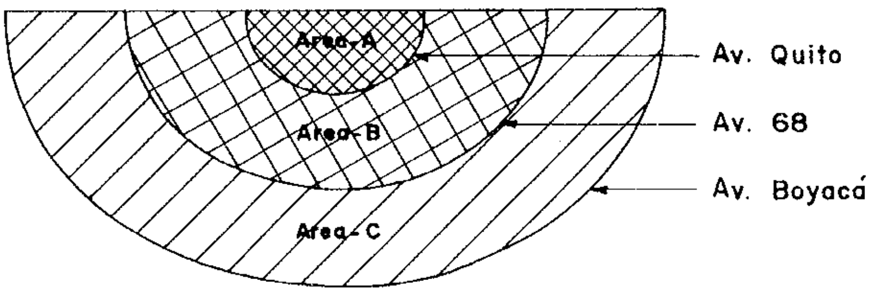


Figure 10.2-1 Person Trip Movement in 1995 and 2020

Table 10.2-1 Traffic Characteristics of Each Area

Condition Items	Unit	Area-A	Area-B	Area-C
Land Area(A)	km2	15.1	34.0	23.4
Road Length(B)	km	73	82	48
Road Ratio(B/A)	km/km2	4.9	2.4	2.1
Land Use Condition		Urbanized(CBD)	Urbanized	Sub-Urban
Housing Condition		High Density	Medium Density	Low Density
Road Side Condition		High Use	Medium Use	Low Use
Traffic Conditions				
1) PCU-km		4,792,000	5,487,000	3,620,000
2) Person-km		35,102,000	36,302,000	27,444,000
3) PCU-hours		244,000	135,000	134,000
4) Average Speed	km/h	19.0	40.5	26.9
5) Congestion Degree		0.906	0.658	0.702
6) PCU-km/Land Area		317,000	161,000	154,000
7)PCU-km/Road Length		65,000	67,000	75,000

PCU: passenger car unit



	TRAFFIC CONGESTION RATE	AVERAGE RUNNING SPEED	PCU: Km	PARSON: Km
Area - A	0.906	19.60	4.793.000	35.102.000
Area - B	0.658	40.50	5.487.000	36.302.000
Area - C	0.702	26.90	3.621.000	27.444.000

Figure 10.2-2 Location of Each Area

10.2.3. Traffic Volume on Trunk Roads in Bogota (1995)

The traffic volume on the trunk roads in Bogota is presented in Table 10.2-2 based on the results of traffic count survey which was conducted by JICA in 1995.

Table 10.2-2 Traffic Volume on Trunk Roads in Bogota (1995)

Name of Road	PCU/12h (A)	PCU/24h (A)*1.3= (B)	PCU/h (peak hour) (C)	Capacity (PCU/h) (D)	Congestio n Degree (C/D)
Av. Quito(RN)	153,000	198,900	15.100	10,000	1.5
Auto. Norte(RA)	128,000	166,400	15,300	10,000	1.5
Av. 7a(RA)	116,300	151,200	7.800	4,200	1.9
Auto. Americas(RA)	96,100	124,900	9,300	7,600	1.2
Auto. El Dorado(RA)	82,600	107,400	9,100	7,600	1.2
Av. Boyaca(RN)	74,600	97,000	7,400	7,600	1.0
Av. 68(RN)	68,500	89,100	6,800	7,600	0.9
Auto. Sur(RA)	61,300	79,700	5,800	2,800	2.1
Auto. Medallin(RA)	47,000	61,100	5,000	2,800	1.8
Av. Cirucunvalar(RA)	46,000	59,800	4,000	2,800	1.4
Av. Caracas(RA)	45,600	59,300	5,100	4,200	1.2
Av. Centenario(RA)	47,700	62,100	4,800	2,800	1.7

(RN) ; Ring Road Network, (RA) ; Radial Road Network

From the above Table 10.2-2, the following matters are pointed out.

1) During peak hour, traffic volume on almost all the trunk roads in Bogota City exceeded capacity. The traffic congestion degrees of these roads were about 1.0 to 1.9.

2) Implementation of some improvement plans for mitigation of traffic congestion, such as widening of existing road, strengthening of public transport system are required on all trunk roads in the city of Bogota.

3) The following four (4) roads, that is, Autopista Medellin, Autopist Sur, Avenida Centinario, Avenida Cirucunvalar should be especially improved from 4-lane roads to 6-lane or 10-lane roads in accordance with the road design standards in Colombia. These existing roads are maintained as 4-lane to 6-lane roads, and there is sufficient space for widening of these existing roads.

10.2.4. Traffic Volume on the Boundary of Bogota

As a result of the Transport Master Plan in Bogota, the socioeconomic framework of the Master Plan indicated that the population in the surrounding cities will be increased from 800,000 in 1995 to 2,400,000 in 2020. The future travel demand for traffic flows into Bogota by persons who dwell outside Bogota will rise to approximately 3 times compared with in year 1995. Table 10.2-3 shows the traffic volume on the boundary of Bogota.

The increase of traffic volume in 2020 on the boundary of Bogota is 3.64 times the volume in 1995. The increase in the northwest, and west directions (Cota, Tenjo, Funza, Mosqura, Madrid, and Bojaca) is even higher at 3.33 times the volume in 1995. the increase is less in the south direction (Soacha) because the volume in 1995 is low. The increase in the north and southwest direction is 3.16 and 2.18 times the volumes in 1995. See Figure 10.2-3.

Table 10.2-3 Traffic Volume on the Boundary of Bogota by Direction

Direction	City	Major Roads	1995	2001	2010	2020	2020	Increase Ratio		
			unit : 100 PCU/day				1000 persons	2001/1995	2010/1995	2020/1995
North	Chia	Autopista Norte	153	163	212	428	124			
	Cajica	Av. Boyaca Expansion	173	185	271	602	160			
		Total	326	348	483	1,030	284	1.07	1.48	3.16
Northwest	Cota	Av. San Jose	-	-	-	507	101			
West	Tenjo	Av. Cota	99	246	510	164	23			
	Funza	Autopista Medellin	152	309	448	610	78			
	Mosquera	Av. Jose Celestion	-	-	-	68	9			
	Madrid	Av. Centenario	558	290	359	131	49			
	Bojaca	Autopista las Americas	-	-	-	929	201			
		Avenida 1 de Mayo	-	-	105	287	47			
		Total	809	845	1,422	2,696	508	1.04	1.76	3.33
Southwest	Soacha	Autopista Sur	68	70	74	148	54			
		Total	68	70	74	148	54	1.03	1.09	2.18
South	Sumapaz	Av. Circunvalar	47	47	52	148	56			
	Caqueza	Autopista al Llano		288	343	512	82			
		Camino de Pasquilla				12	13			
		Total	47	335	395	672	151	7.13	8.4	14.3
		Grand Total	1,250	1,598	2,374	4,546	997	1.28	1.9	3.64

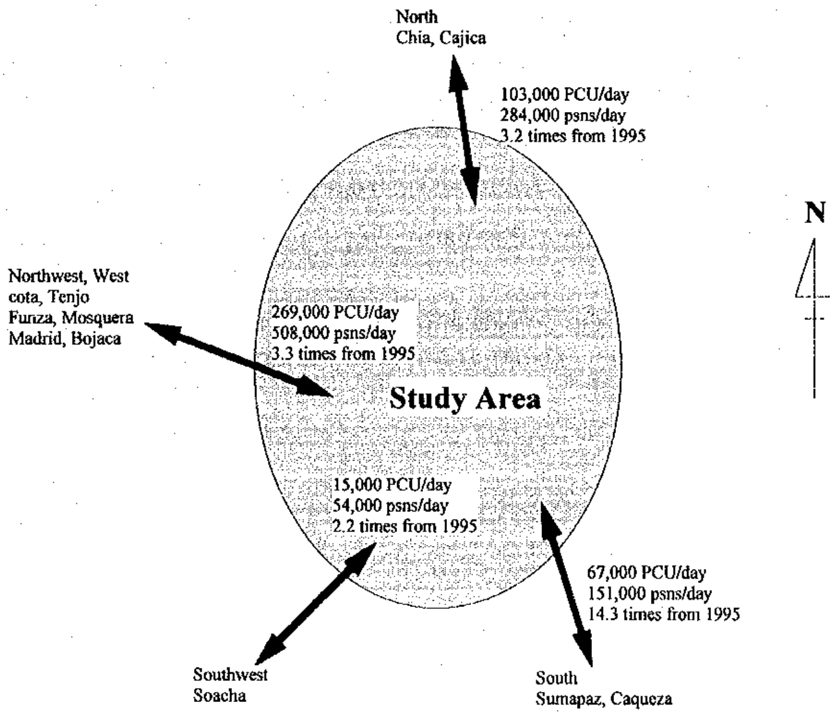


Figure 10.2-3 Traffic and Passenger Volumes on the Boundary of Bogota

From the above mentioned table and figure, the following observations are derived.

1) By the year 2020, urban development progress of Bogota city and its surrounding cities will make these units closer, and these cities will become part of a Greater Bogota Metropolitan Area

2) Economic activities between Bogota and it surrounding cities will be reinforced rapidly, and the traffic movement between Bogota city and its surrounding cities will concentrate on the existing trunk radial roads.

3) Therefore, the existing trunk radial roads such as Autopista Norte, Avenida Suba, Autopista Medellin, Avenida Centenario, Autopista Americas, Avenida Primera Mayo, and Autopista Sur should be rehabilitated in accordance with the road design standards of Colombia as soon as possible.

4) Cundinamaruca road should be constructed as the Outer Ring Road of Bogota to connect to the Autopist Sur, Basa, Kennedy, Fontibon, Suba, and Autopista Norte.

5) Additionally, Cundinamaruca road will be extended to the Usme direction for the completion of the Outer Ring Road of Bogota City in the future.

10.2.5. Relationship between Traffic Characteristics and Road Network in Bogota

The future traffic volume projection in 2020 was forecasted in the Master Plan Study. As mentioned in the Final Report in the Master Plan Study, the assignment of traffic volume in 1995 and in 2020 on the major existing road network is shown in Figure 10.2-4. According to this figure, the following items were pointed out.

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

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

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

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

5) Based on the above, the construction of new roads are required in the sub-urban area of Bogota, and the existing trunk radial and ring roads should be improved.

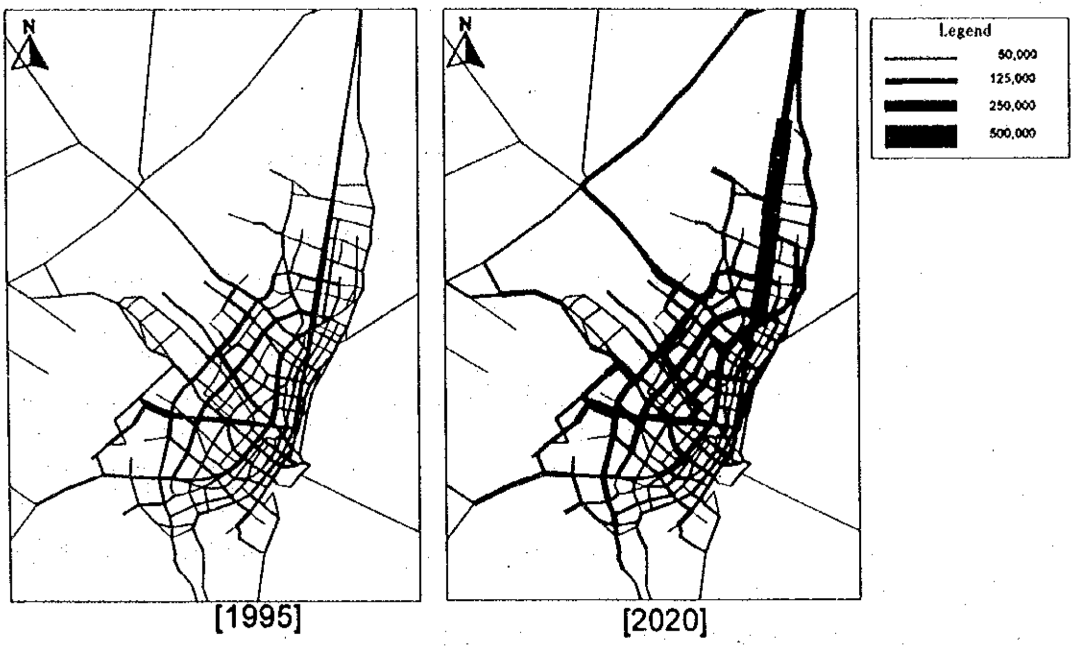


Figure 10.2-4 Future Traffic Volume Assignment on the Existing Major Roads

Based on the analysis of above-mentioned matters, the road network conceptual plan was identified as shown in Figure 10.2-5. The major road network planning concept in Bogota was identified taking into account the existing road network, the function and characteristics of a roads, future socioeconomic conditions, and future land use plan.

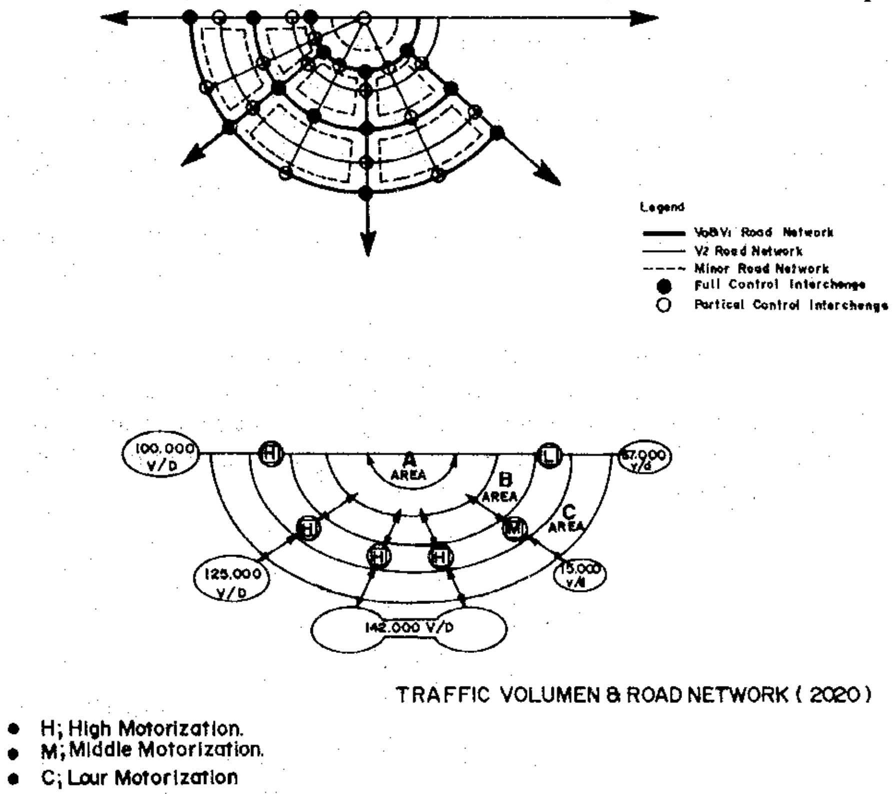


Figure 10.2-5 Road network System Configuration

10.3. NECESSITY FOR INNER RING EXPRESSWAY

From viewpoint of traffic and transport conditions in the city of Bogota, the traffic congestion of central area in Bogota covered by Avenida 7, Calle 100, Avenida Quito and Calle 6 is very heavy and the traffic conditions of this area will get more critical due to the increasing traffic volume day by day. The average traffic congestion rate of central area in 1995 was estimated as 0.906, and average running speed in peak hour in the central area was estimated as about 5 to 7 km/h.

On the other hand, the road ratio (road area/ total land area) including trunk roads and feeder roads of central area is calculated at about 24.5 % and this road ratio is presented as comparatively good road ratio among the cities of the world.

The land use along the existing roads in the central area is classified as business and commercial area and there are many tall buildings along the existing road on both sides. There is no room to construct of new roads in this area, and it is very difficult to widen the existing roads due to the many buildings which have been constructed along the existing roads.

Considering the above mentioned conditions, the necessity for the Inner Ring Expressway are highlighted as follows:

1) Increasing the traffic capacity in the central area is required.
2) There are some methodologies for increasing the traffic capacities as follows,
   a) Widening of the existing roads
   b) Construction of new roads
   c) Strengthening of public transport
   d) Implementation of traffic management
   e) Implementation of traffic demand control (TDM)
3) However, it is very difficult to widening of the existing roads and also to construct new roads because of lack of space for road construction, and the reinforcement of public transport and implementation of traffic management plan or TDM were carried out already in the central area of Bogota.
4) Therefore, utilization of existing roads for multi-purposes is required to increase the traffic capacities in the central area of Bogota. This is the Inner Ring Expressway
5) As mentioned in Final Report of the Master Plan Study, when the Urban Expressway network will be constructed, traffic volume on the existing roads will be decreased as shown in Table 10.3-1. By decreasing the traffic volume on the existing roads, sufficient urban activities and good environmental aspects of the city can be recovered.

Table 10.3-1 How Will the Traffic Volume on Major Roads Charge when Urban Expressway will be constructed. (in 2020 pcu/day)

Road Name	Traffic Volume with Urban Expressway	Traffic Volume without Urban Expressway	Changing Traffic Volume
1) Av. Caracas	42,400	88,700	56,300
2) Av. 7a	45,100	111,500	66,400
3) Av. 7a Nort	15,800	29,700	13,900
4) Calle 11	21,000	30,300	9,300
5) Av. Quito	169,700	171,400	1,700
6) Calle 100	120,600	157,700	37,100
7) Calle 68	188,000	199,800	1,800
8) Av. Boyoca	101,100	122,500	21,400
9) Aut. Norte	224,000	251,300	27,300
10) Aut. Medellin	78,300	79,900	1,600
11) Aut. Dorado	170,100	207,700	37,600
12) Aut. Americas	142,900	197,500	54,600
13) Aut. Sur	73,400	77,600	4,200

10.4. POLICIES AND STRATEGIES FOR PLANNING

Inner Ring Expressway will be constructed using the existing road space or vacant areas of urbanized area as over passes or under passes of the existing roads. The existing trunk roads will have trees planted on the median or on the sidewalks of the trunk roads, thus enhancing the urban and natural environmental conditions. On the other hand, there are many buildings along the existing road on both sides in the central area of Bogota.

The objectives of construction of Inner Ring Expressway are to mitigate the traffic congestion in the central area of Bogota and to coordinate the other transport systems such as bus transport and railway transport systems. Based on the above, the following items are identified as policies and strategies for planning of Inner Ring Expressway.

1) To preserve the historical buildings and monuments
2) To keep the natural and social environment
3) To meet the urban perspective
4) To meet the future traffic demand and to keep the traffic safety
5) To improve the transport system

In order to achieve the above-mentioned policies, the following study strategies are identified.

1) The necessity for Inner Ring Expressway should be recognized by the public.
2) The relationship between environmental aspects and development of road construction should be clarified.
3) Various alternative studies should be carried out to clarify the situation.
4) Advertising and announcing plan of Inner Ring Expressway should be conducted.

10.5. PREMISES FOR PLANNING

Based on the following premises for planning, the feasibility study of the Inner Ring Expressway is conducted.

1) The Study for the Master Plan for Urban Transport of Santa Fe de Bogota was conducted by JICA during the period from 1995 to 1996. In this Master Plan, the Urban Expressway Network in Bogota were recommended as the short and long term plan for mitigation of traffic congestion of Bogota city. The Urban Expressway Network consists of the Inner Ring Expressway, the 2nd Ring Expressway and four (4) Radial Expressways.

2) Of all the elements of the Urban Expressway Network in the Master Plan, the Inner Ring Expressway project is selected for implementation in the Feasibility Study for Urban Expressway development as an urgent plan. The study route for feasibility study is actually the Inner Ring Expressway.

3) The planning target year of the Inner Ring Expressway is adopted as the year 2005.

4) The dimensions or capacity of elements of infrastructure on the Inner Ring Expressway such as number of lane required, lanes width, are determined on the basis of future traffic volume in 2015.

5) By the year 2000, the following trunk bus system will be operated.

   a) Avenida Caracas

   b) Autopist Norte

   c) Avenida 80

   d) Ferrocarril Sur

6) By the year 2005, the following trunk bus system will be operated.

   e) Avenida Boyoca

   f) Autopista Las Americas

   g) Avenida Centenario

7) By the year 2000, the following trunk roads will be constructed.

   h) Cundinamaruca toll road

   i) Avenida Boyoca extension

8) The construction schedule of railway project is as follows,

   j) Stage 1 of railway will be completed by the year 2005.(Bosa to Centro)

   k) Stage 2 of railway will be completed by the year 2010. (Centro to Calle 68)

9) The preliminary design of Inner Ring Expressway is conducted based on the topographic map of scale at 1 to 5,000.