# CHAPTER 6
# Future Transport Demand Forecast

# 6. FUTURE TRANSPORT DEMAND FORECAST

## 6.1. GENERAL

In addition to the Master Plan Study, there are several new on-going transport projects proposed by related agencies. Among those projects are the SITM railway study, STT Transmilenio project for trunk busway, Cundinamarca toll road project, etc. These projects, if constructed, would affect the forecasted travel demand on major projects in the Master Plan. Therefore, it is necessary to forecast the future travel demand of public transport on the trunk busway and the expressway taking into account Metro-Line No.1 of SITM's railway system and others.

Travel demand forecast of public transport on the trunk busway and the expressway will be conducted based on new transport and road network incorporating on-going projects. The travel demands on the busway and expressway are strongly affected by the SITM railway transport projects whether implemented or not. Therefore, in the Study, traffic demand is forecasted on the following assumption:

- Stage 1 of SITM railway project to be completed in the year 2005.
- Stage 2 of the project complets in the year 2010.

In the Study, the public transport demand is estimated on the travel conditions in the peak hour, but for an economic analysis, daily base was used. This is because the public transport planning of bus operation system such as service frequency, bus lines, number of bus fleet is critical in the peak hour. Therefore, the future morning peak hour OD trip data is estimated based on the future daily OD trip data forecasted in the Master Plan study.

In this Chapter, the outline of future travel demand forecast is first, estimated on the Study on the Master Plan for Urban transport of Santa Fe de Bogota. Next, both future OD trip data of SITM's study and this Study are compared and adjusted considering the development effect of railway project. The last subject of this Chapter is the forecasting method for peak-period trip distribution. The peak hour OD trip table is estimated based on the Person Trip survey data which has departure and arrival time in each trip data.

## 6.2. TRAVEL DEMAND FORECAST

In the Master Plan Study, the 2020 year is defined as the target year. The future socioeconomic frame and demand forecast are estimeted in the 2020 target year. This Feasibility Study is conducted in the target year of 2005. Therefore, the travel demand forecast in 2005 is estimated as a short-term by using the estimated OD trip table in 2020 without forecasting socioeconomic frame in 2005. This is because the basic study conditions of the F/S Study succeed the basic data of the Master Plan. The F/S Study is conducted as a short-term plan, based on the future urban development plan in 2020 as a long-term framework.

### 6.2.1. SOCIOECONOMIC FRAMEWORK

#### (1) Future Population and GRDP

Future population and economic growth in 2020 are shown in Table 6.2-1. Those figures are estimated in the Master Plan study. This Study uses the same socioeconomic frame as that of the Master Plan study.

Table 6.2-1 shows the 2020 population distribution plan for Study area. The future population of the Study Area will reach 8.6 million in 2020 and will increase by 1.44 times during the 25 -year period after 1995. The net migration into the Study Area will gradually decrease from 300,000 persons per 5 years to almost the balance level (4,000 persons) in 2020. The total population of surrounding cities such as Cajica, Chia, Cota, Funza, Mosqueira, and Soacha is forecasted at 2.4 million in 2020, and the population of the Bogota Metropolitan Area will reach at 11.0 million in 2020.

The future annual economic growth rate of the Study Area is determined to be 5.2 % as the target for the improvement of the total urban environment of the Capital City. The share of the national GDP will rise to 22 %.

Table 6.2-1 Future Population in the Study Area

| Area | 1995 | 2020 |
|---|---|---|
| (1) Study Area | | |
| Usaquen/Suba | 960,000 | 2,500,000 |
| Fontibon/Engatiba | 1,152,000 | 1,500,000 |
| Bosa/Kenedy/C.Bol | 1,289,000 | 1,850,000 |
| Teusaquillo | 166,000 | 250,000 |
| Others | 2,428,000 | 2,500,000 |
| Sub-Total | 5,995,000 | 8,600,000 |
| (2) Surrounding Cities | 816,000 | 2,400,000 |
| (3) Total | 6,811,000 | 11,000,000 |

### (2) Urban Development Pattern

The present urban structures of Bogota can be called a mono-nucleated pattern, although the business/commercial district extends to the north through Chapinero towards Usaquen. For the future urban development pattern of Bogota, the following three (3) patterns could be considered.

a) Mono-nucleated Pattern

b) New Town Pattern

c) Poly-nucleated Network Pattern

The Mono-nucleated Pattern will worsen the existing traffic problems. On the other hand, the New Town Pattern is very difficult to realize, and it is feared that the economic activities of Bogota will lose their vitality if mobility in the area declines too much. It is considered that the Poly-nucleated Network Pattern is the most realistic and can be developed by making efforts to strengthen the present policies for planning and development.

## 6.2.2. FUTURE TRANSPORT DEMAND

### (1) Increase of Person trips

As mentioned before, the future person trips were estimated by a person trip base-method in which the future person trips in the middle years between the trips in 1995 and 2010 forecasted in proportion of middle years.

The total number of person trips per day in the Study Area in 2005 is forecasted at 12.6 million. The trip increase rate will be 1.07 times from 1998 to 2005, while the trip increase rate in 2010 will be 1.15 times. Summary of travel demand is shown in Table 6.2-2.

As for the future trips by mode: private and public modes, number of trips by mode (private and public) in the years 1998 to 2010 are also shown in Table 6.2-2. The increase ratios of trips from 1998 to 2005 by mode are 1.06 for public mode and 1.11 for the private. As can be seen, the future growth of public transport is lower than that of the private.

Table 6.2-2 Future Travel Demand by Mode

(Person trips /day)

| Types | 1998 | 2000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|---|
| Car | 2,321,859 | 2,395,140 | 2,641,129 | 3,026,796 | 3,714,971 |
| Taxi | 612,109 | 618,867 | 659,359 | 747,465 | 929,521 |
| Truck | 326,813 | 317,504 | 330,595 | 377,755 | 480,390 |
| Private | 3,260,781 | 3,331,511 | 3,631,083 | 4,152,016 | 5,124,882 |
| Public | 8,463,196 | 8,581,050 | 8,936,628 | 9,410,547 | 10,092,242 |
| Total | 11,723,977 | 11,912,561 | 12,567,711 | 13,562,563 | 15,217,124 |
| Private (%) | 27.8% | 28.0% | 28.9% | 30.6% | 33.7% |
| Public (%) | 72.2% | 72.0% | 71.1% | 69.4% | 66.3% |

### (2) Trip Generation and Attraction

Estimated trip generation and attraction by all modes according to the integrated zone are shown Figure 6.2-1. The Figure shows a comparison between the figures in 1998 and 2005. As can be seen, the increase rates of trip generation between 1998 and 2005 in northern and western areas are considerably higher (1.2- 1.5), while in central area they are slightly higher (1.05 – 1.06).

As for trip attraction, the increase rate of the central area is higher (1.08 – 1.10), in contrast to 1.05 – 1.06 of the generation. In the northern area, the figures are also higher (1.26 – 1.46). This is because work-place/school-place base population (employment) is substantially concentrated in the central area when the distribution of population is compared.

### (3) Trip Distribution

Figure 6.2-2 illustrates the desire lines by all modes for interzonal trips in 1998 and 2005. As seen, heavy trip flows in 2005 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 1998, OD trips in 2005 linked between the central and suburban areas in the fringe of Bogota increase considerably.

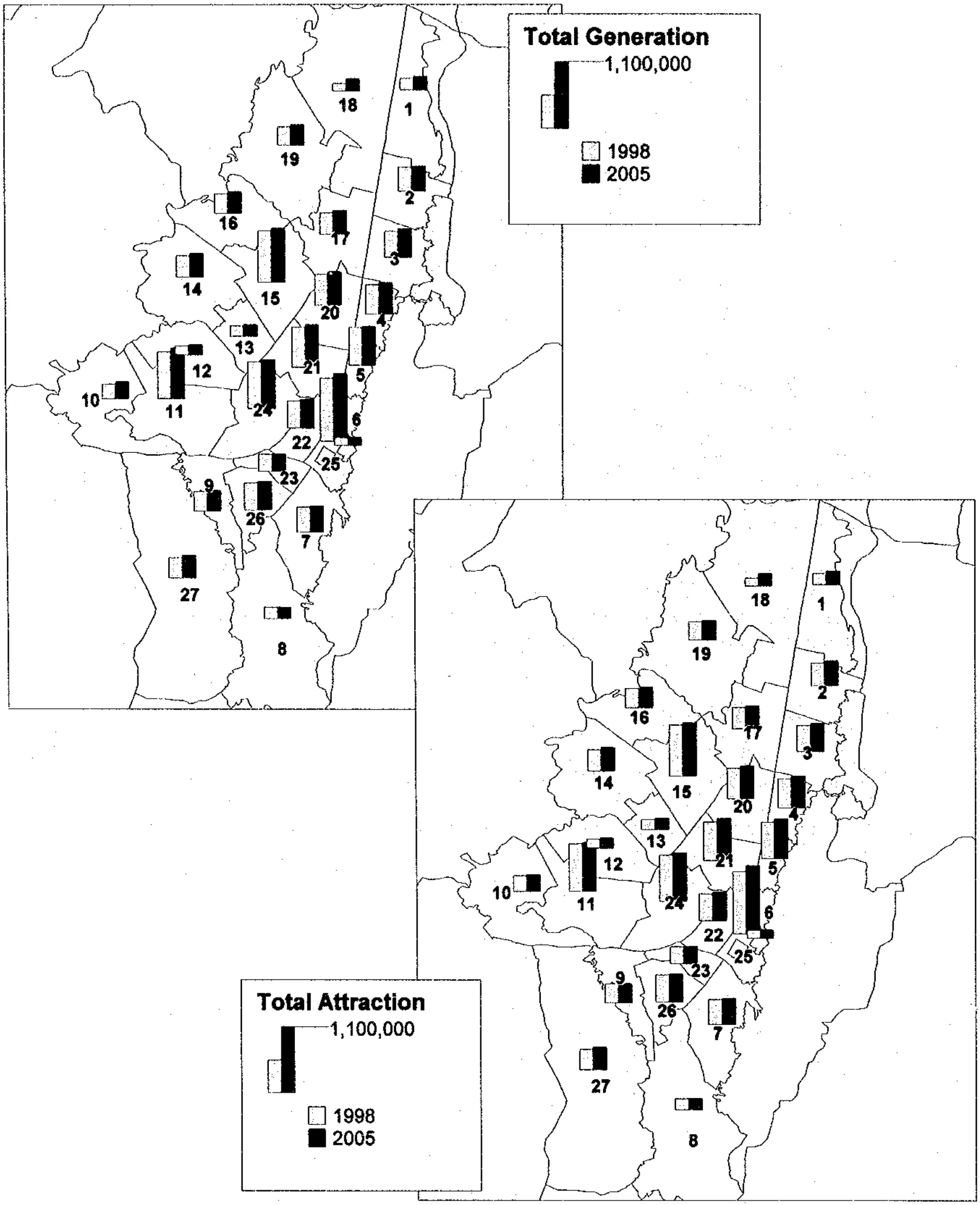



Figure 6.2-1 Trip Generation and Attraction in 1998 and 2005

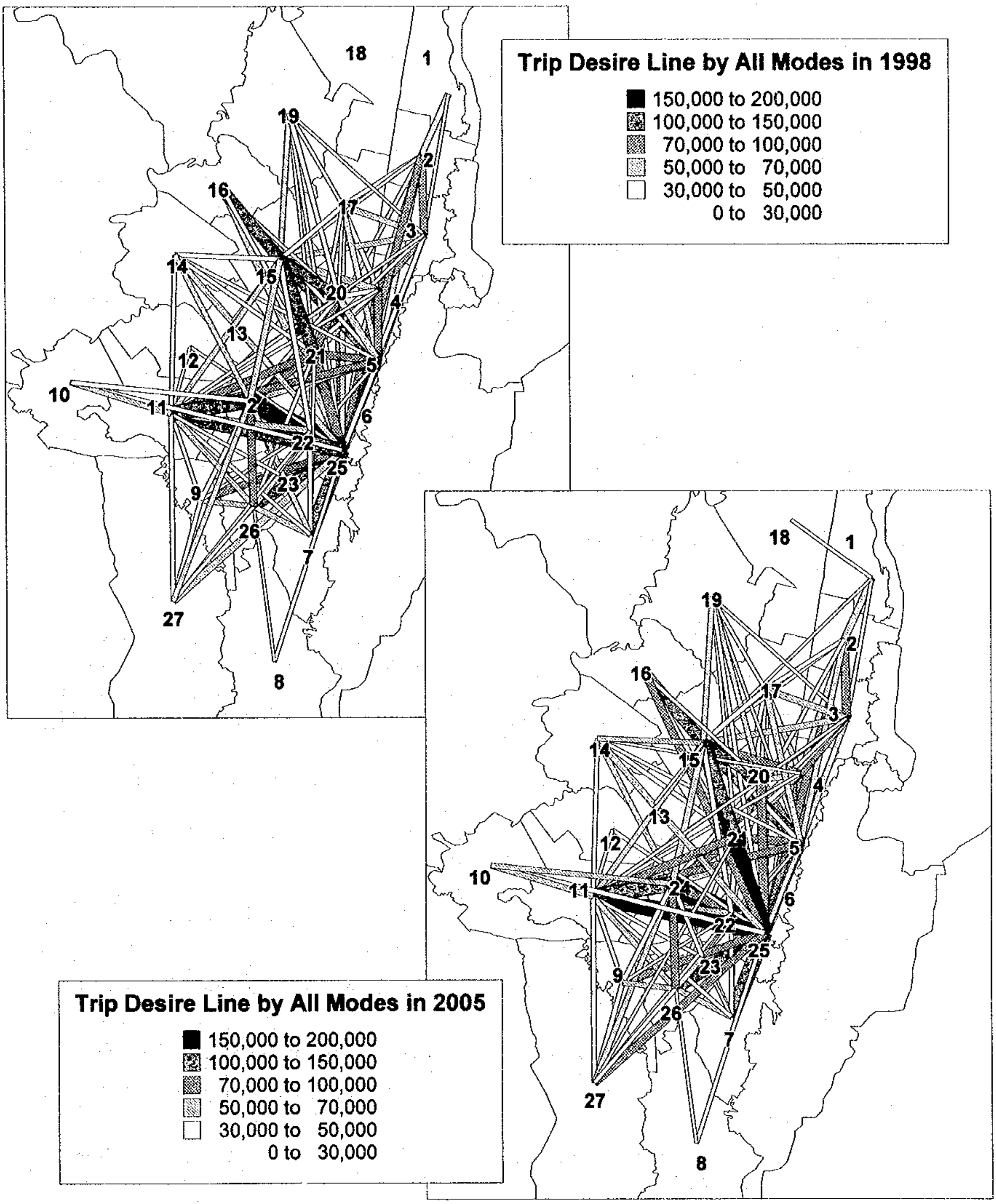



Figure 6.2-2 Trip Desire Line by All Modes (1998/ 2005)

### 6.2.3. INFLUENCE OF SITM'S PROJECT

As before- mentioned, the influence of SITM railway project is large in terms of travel demand on the trunk bus system, especially on competitive busway which is planned with a parallel way to the railway. In this SITM railway study, the development effect has been analyzed and future demand has been forecasted. On the other hand, in the JICA Master Plan Study the influence of the railway project is not specifically taken into account because SITM railway study commenced after completion of the JICA Master Plan Study. The development influence of railway project on travel demand will take effect after several years, not immediately. Therefore, it is necessary to take into account the development effect in the travel demand in the year 2010 or later in this F/S Study.

In order to forecast travel demands for the railway project in this Study, future travel demand by SITM study is analyzed and a part of OD trip data by SITM study was utilized without directly estimating future travel demand by railway project. This is because the development effect by the railway has been estimated in SITM study and this estimated demand is employed as travel demand by railway. Therefore, it is possible to adjust the demands of railway project by both studies. The procedure of incorporation with both OD trip data by SITM study and this Study is shown in the following section.

Transmilenio project was incorporated into the trunk busway network as a part of the trunk bus system and bus passenger demands on the project were forecasted with the bus transit assignment model.

#### (1) Procedure of Incorporation

Figure 6.2-3 shows the procedure of incorporating travel demand affected by SITM project with the future travel demand in the Study.

As can be seen, trip OD tables forecasted by SITM's project are peak hour trip OD tables in 2002, 2006 and 2016 on 99 zone system. The SITM's trip OD tables are directly taken into account the developing travel demand by the railway projects. Those trave demand are forecasted on the assumption that the stage 1 of railway project will be completed by 2002, and the stage 2 be in 2006.

On the other hand, this Study is carried out on the precondition that in the year 2005 the stage 1 railway project completes, while for the stage 2 in 2010. Therefore, the trip OD table in 2005 is coped with SITM's trip OD table in 2002, while 2010 demand for 2006 SITM's demand on adjustment of both total trips.

The procedure taking into account influence of SITM's projects is as follows. In this steps, both trip OD tables are forecasted in the morning peak hour. The estimation method for peak hour OD trip table of this Study shows in the next Section 6.3.

1) Adjustement of both total trips: SITM's total trips are coincided with the future total trips by the Study.
2) Comparing trip generation and attraction between the Study and SITM's OD tables.
3) Identifying influenced zones for railway projects in terms of trip generation and attraction.
4) Adding difference between the Study and SITM's trip generation and attraction on the Study OD table.
5) Completing the future OD tables in 2005 and 2010 taking into account SITM's project.

## (2) Projection of Travel Demand

### *1) Influenced Area*

Figure 6.2-4 shows comparing trip generation and attraction between the Study and SITM's OD tables in 2005. The influenced areas where differences of trip generation and attraction by railway project are large are along the planned railway. Travel demands in Bosa and Kennedy somewhat rise comparing to others.

### *2) Developed Travel Demand*

Table 6.2-3 shows the hourly trip generation and attraction for developed travel demand. The numbers of person trips in the morning peak hour in the generation and attraction are approximately 35,000 and 18,000 trips which are equivalent to 3.6% and 1.9%, respectively. Those developed travel demands are added on the Study OD tables.

Table 6.2-3 Developed Travel Demand by Railway in 2005

(Unit: person trips/hour)

| Items | | Trips | Ratio to Total |
|---|---|---|---|
| Developed Demand | Generation | 35,167 | 3.6% |
| | Attraction | 18,303 | 1.9% |
| Total Trips (excluding developed demand) | | 968,771 | |

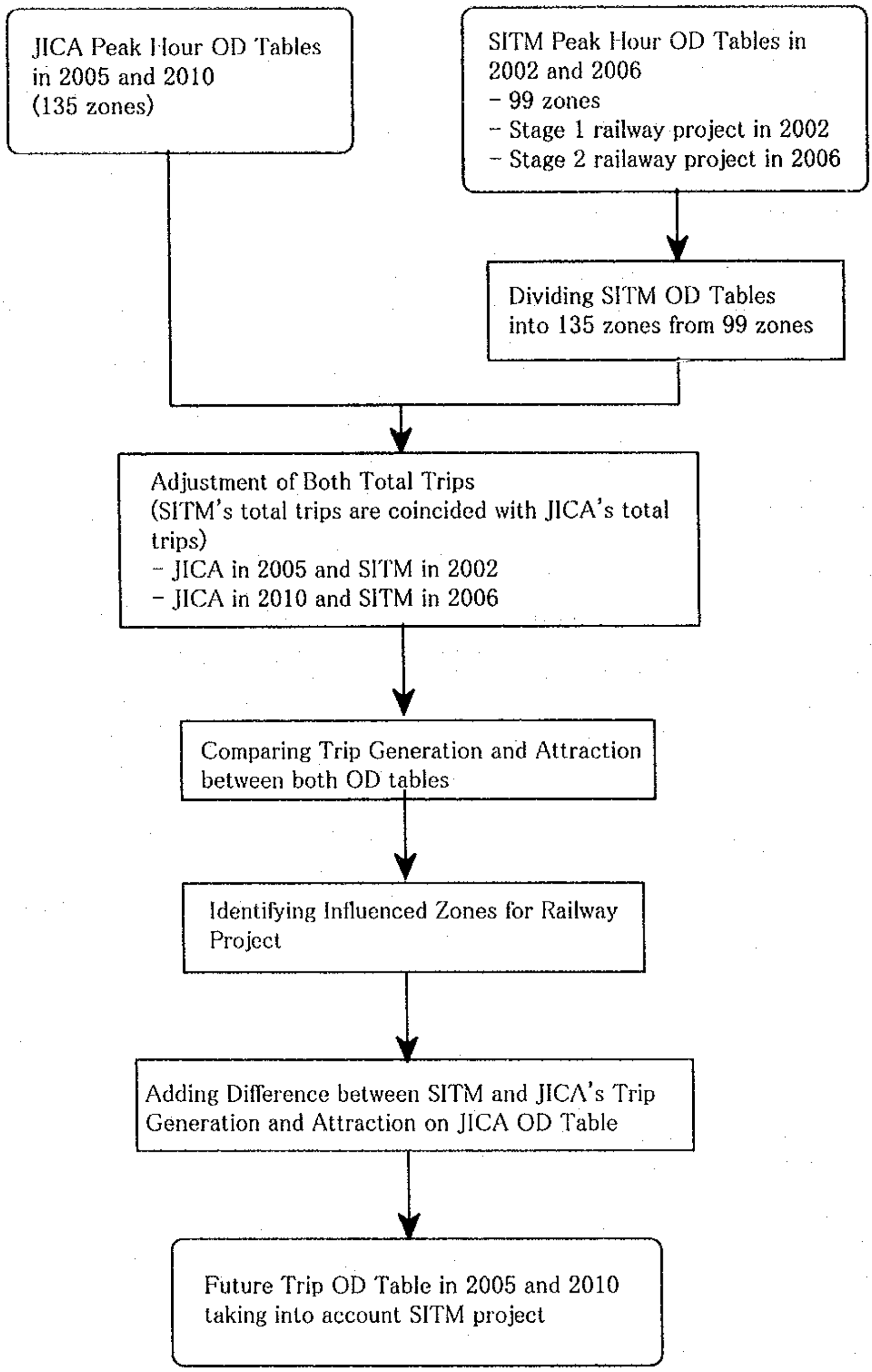



Figure 6.2-3 Procedure of Incorporating Travel Demand Affected by SITM's Project

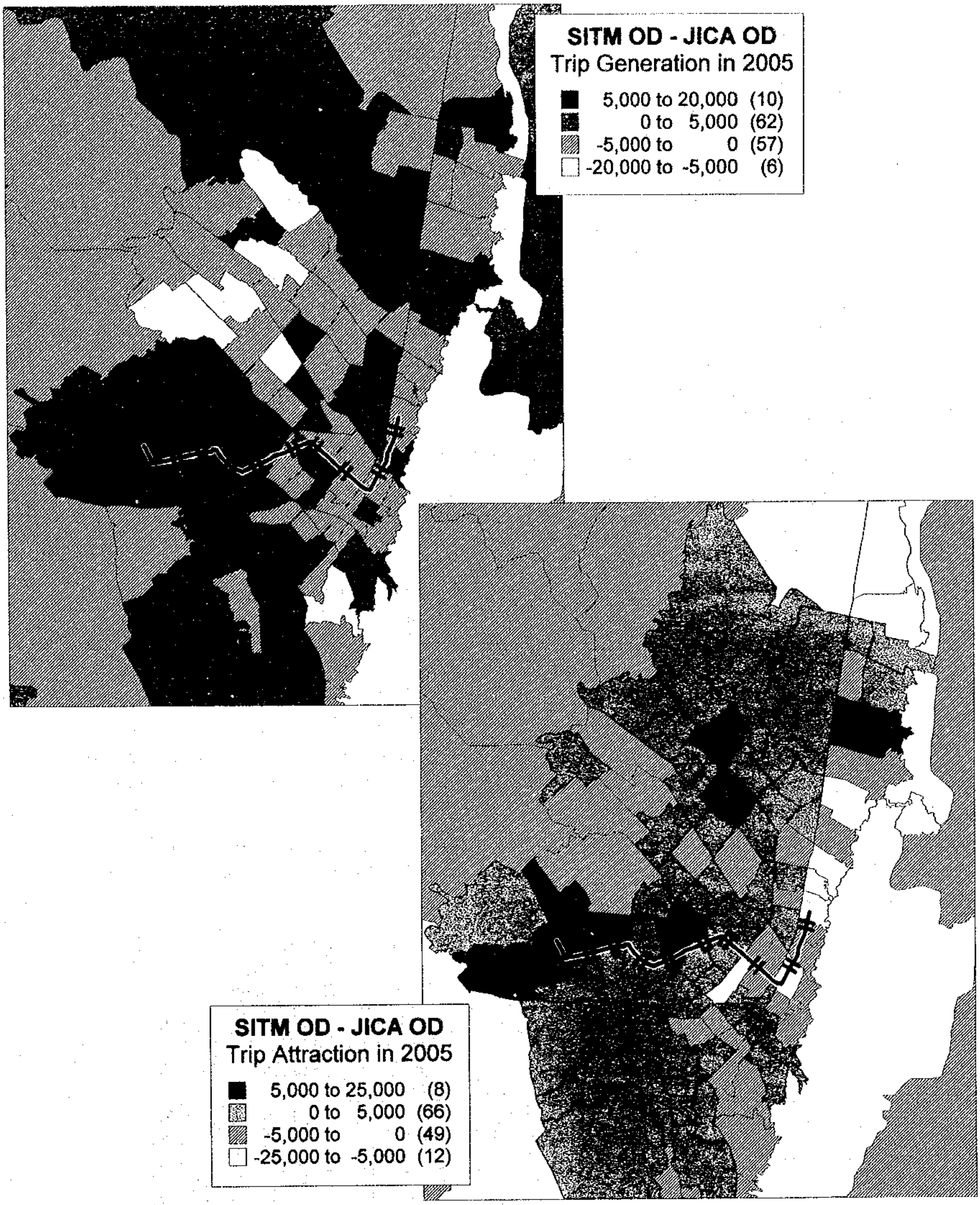



Figure 6.2-4 Comparing Trip Generation and Attraction between the Study and SITM's OD Tables

## 6.3. TRAVEL DEMAND FORECAST IN PEAK-PERIOD

### 6.3.1. PROCEDURE

The estimation of the trunk and feeder bus system is based on the travel demand in the peak hour. The bus operation plan such as bus service frequency on bus route, bus fleet operational needs, busway lanes, bus stop facility, etc. is conducted on the bases of demand in the peak hour, exclusive of economic evaluation on the daily base demand.

Therefore, the peak hour OD trip table is estimated based on the Person Trip survey data which has departure and arrival time in each trip data. The peak hour trips are for a period of 7:00 a.m. to 8:00 a.m. in the morning. Only trip data, traveled during the peak hours are selected from Trip Master data and the peak hour OD trip table is made from these trip data. The OD trips are finally adjusted to the traffic volume in the same peak hour on the screen line.

The future peak hour OD trips are forecasted by multiplying the ratio of present peak hour OD trips to daily OD trips by future daily OD trips estimated in the Master Plan, which are shown in Section 6.2.2.

The peak hour OD trips are estimated on the unit of person trip by mode.

### 6.3.2. PROJECTION OF TRAVEL DEMAND

#### (1) Number of Trips at Peak Hour

The total number of person trips in the morning peak hour in the Study Area in 1998 is forecasted at 1.11 million. The peak hour trip ratio is 9.5%. Summary of travel demand is shown in Table 6.3-1 and Table 6.3-2. As for the trips by mode: private and publuc modes, numbers of trips by mode (private and public) in the year 1998 are 881,000 for public mode and 232,000 for the private. Ratios of peak hour trips to daily trips by mode are 10.4 % for public mode and 7.1 % for the private, respectively.

As for the composition of trip modes, the share of public transport is approximately 79 % in the morning peak hour, in contrast to 72 % for daily unit. In the peak hour, the ratio of public transport is higher than that of daily trips.

The increase in ratios of trips from 1998 to 2005 by mode are 1.16 for public mode and 1.20 for the private. As can be seen, the future growth of public transport in the peak hour is lower than that of private.

Table 6.3-1 Future Travel Demand in Peak Hour

(Person trips /hour)

| Types | 1998 | 2000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|---|
| Car | 176,706 | 185,355 | 211,723 | 247,357 | 297,735 |
| Taxi | 34,304 | 35,918 | 40,810 | 47,395 | 56,540 |
| Truck | 21,143 | 22,060 | 25,153 | 29,921 | 37,871 |
| Private | 232,153 | 243,333 | 277,686 | 324,673 | 392,146 |
| Public | 880,973 | 902,440 | 1,022,237 | 1,076,839 | 1,226,659 |
| Total | 1,113,126 | 1,145,773 | 1,299,923 | 1,401,512 | 1,618,805 |
| Private (%) | 20.9% | 21.2% | 21.4% | 23.2% | 24.2% |
| Public (%) | 79.1% | 78.8% | 78.6% | 76.8% | 75.8% |
| Increase Ratio | | | | | |
| Private | 1.00 | 1.05 | 1.20 | 1.40 | 1.69 |
| Public | 1.00 | 1.02 | 1.16 | 1.22 | 1.39 |
| Total | 1.00 | 1.03 | 1.17 | 1.26 | 1.45 |

Table 6.3-2 Peak Hour Ratio

| Types | 1998 | 2000 | 2005 | 2010 | 2015 |
|---|---|---|---|---|---|
| Car | 7.6% | 7.7% | 8.0% | 8.2% | 8.0% |
| Taxi | 5.6% | 5.8% | 6.2% | 6.3% | 6.1% |
| Truck | 6.5% | 6.9% | 7.6% | 7.9% | 7.9% |
| Private | 7.1% | 7.3% | 7.6% | 7.8% | 7.7% |
| Public | 10.4% | 10.5% | 11.4% | 11.4% | 12.2% |
| Total | 9.5% | 9.6% | 10.3% | 10.3% | 10.6% |

### (2) Trip Generation and Attraction at Peak Hour

Figure 6.3-1and Figure 6.2-2 show the trip generation and attraction in the morning peak hour in 1998 and 2005 by public and private modes, respectively. Table 6.3-3 and Table 6.3-4 also show those figures in 1998 and 2005. The trip generation and attraction by the public mode are considerably different in trip volume. The trip attraction in the central commercial areas: Zones No. 3, 4, 5, 6, 21, and 22, is dramatically higher than the generation in the same zones, while other zones surrounding those zones: residential areas, show that the trip generation is considerably higher than the attraction. The trip ratio of attraction to generation in zones No. 5 and 6 are approximately 4 to 5 times in the morning peak. This indicates that almost all the bus passengers concentrate into the central commercial areas: above mentioned zones, by means of public transportation.

### (3) Trip Distribution at Peak Hour

Trip distribution in the morning peak hour in 1998 by the public and private modes is shown in Figure 6.3-3 and by desire line charts. In these figures, the movement between the zone blocks where trip attraction is predominant: zones No. 3, 4, 5, 6, 20, 21, 22 and 25, and the others surrounding those zone blocks: mainly residential areas, is shown in order to clear the directional movement between each OD pair. The width is proportional to the number of trips between zone blocks.

As can be seen in those figures, large inbound movements by the public and private modes from every residential area located in north, northwest, southwest and south regions to the central commercial areas can be seen in the morning peak hour. On the other hand, outbound movement is low in the trip volume. This indicates that people living in surrounding areas travel into the central areas by means of commuter bus.

Figure 6.3-5 and Figure 6.3-6 show the desire line charts in 2005 by the public and private modes. Those movements show similar patterns with higher volumes than those in 1998.

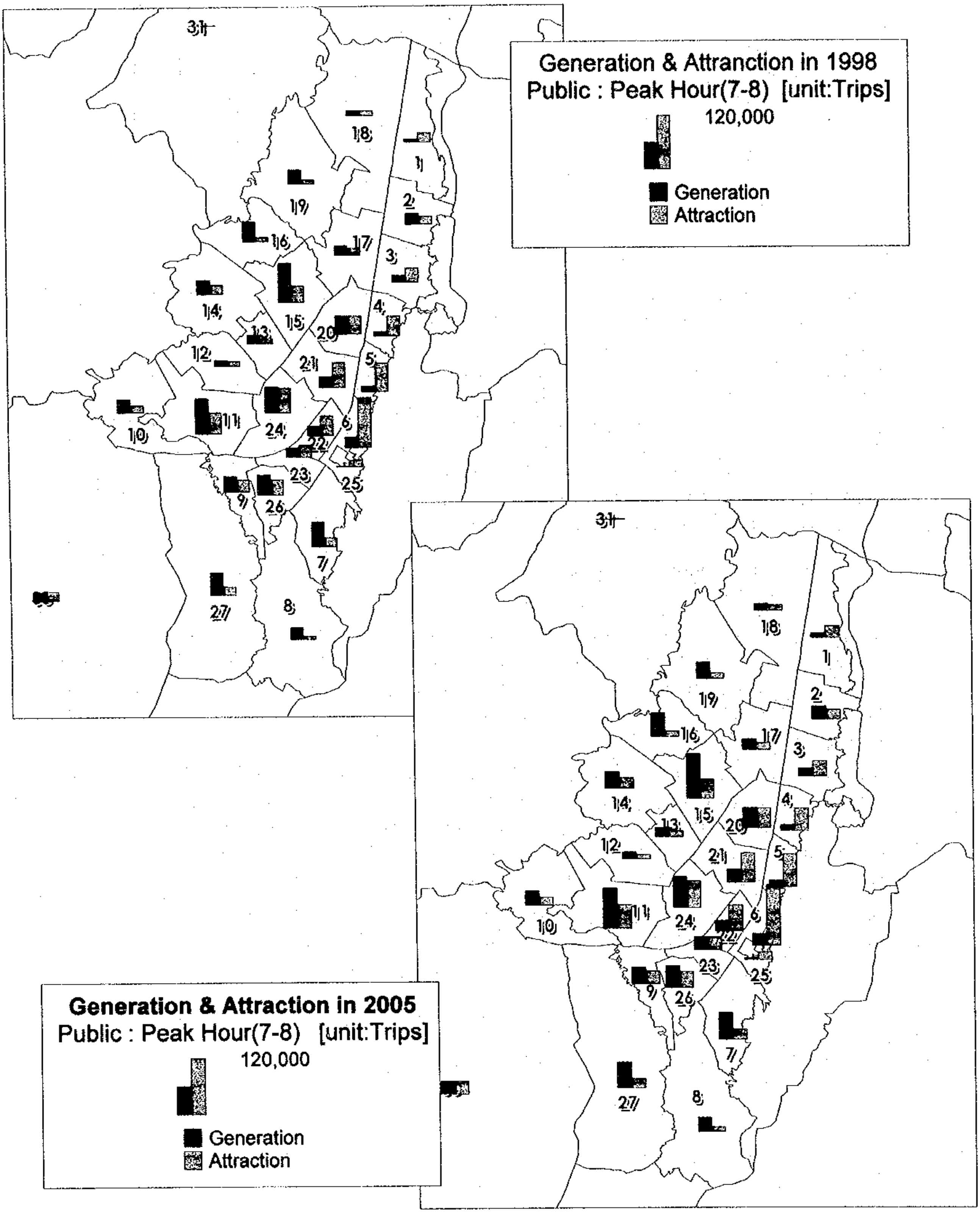



Figure 6.3-1 Peak Hour Trip Generation and Attraction by Public Mode in 1998 and 2005

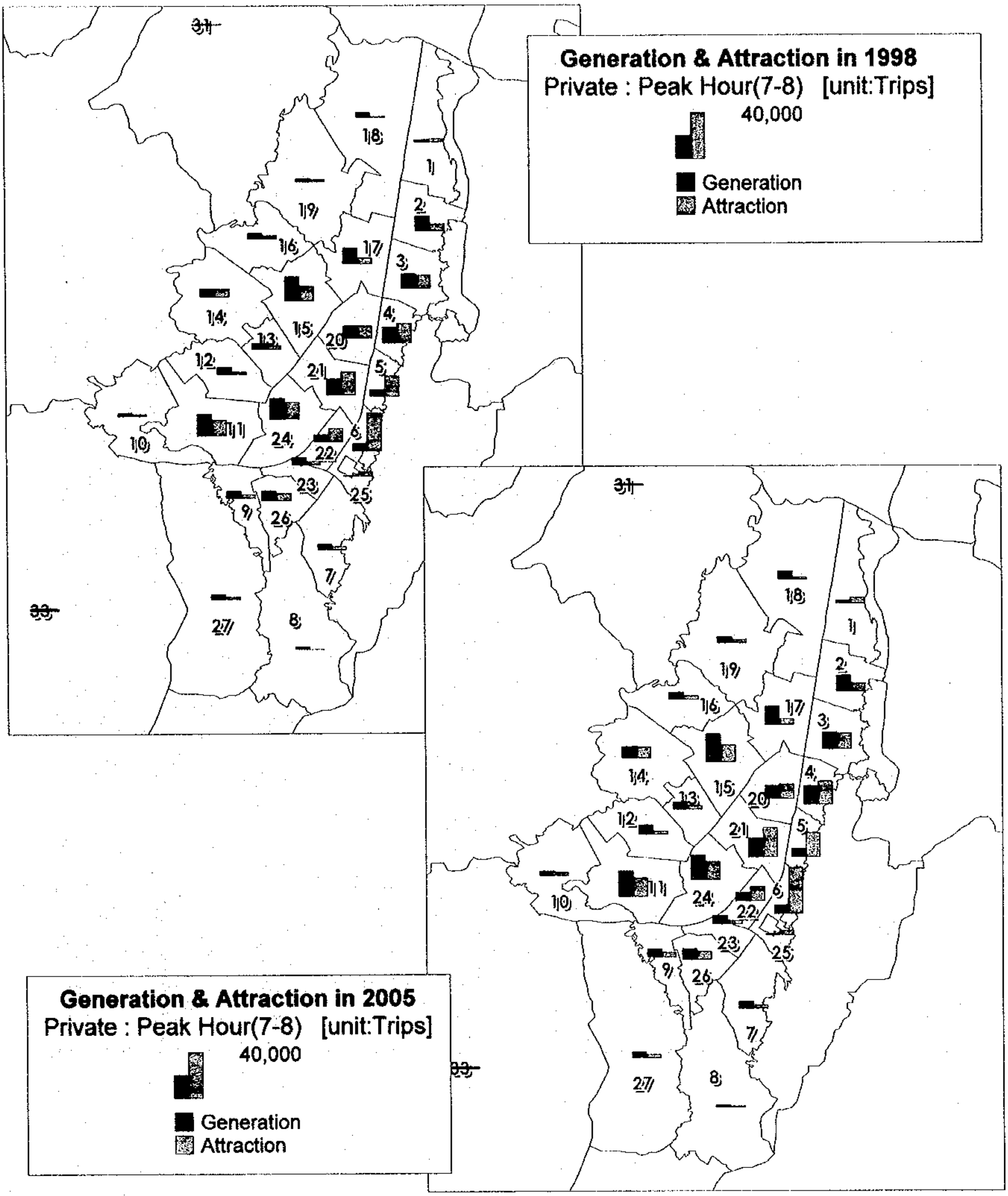



Figure 6.3-2Peak Hour Trip Generation and Attraction by Private Mode in 1998 and 2005

Table 6.3-3 Peak Hour Trip Generation and Attraction by Modes in 1998

(unit:Trips)

| Zone | Generation | | | | Attraction | | | |
|---|---|---|---|---|---|---|---|---|
| | Car | Taxi | Truck | Bus | Car | Taxi | Truck | Bus |
| 1 | 2,078 | 131 | 43 | 7,628 | 3,302 | 62 | 112 | 21,140 |
| 2 | 11,323 | 403 | 516 | 25,272 | 5,337 | 476 | 25 | 19,138 |
| 3 | 11,598 | 682 | 0 | 15,161 | 9,415 | 1,619 | 355 | 31,483 |
| 4 | 11,683 | 1,300 | 363 | 10,636 | 14,061 | 2,106 | 358 | 45,935 |
| 5 | 5,886 | 837 | 0 | 13,247 | 15,489 | 2,748 | 3 | 64,459 |
| 6 | 4,172 | 1,668 | 737 | 22,839 | 26,356 | 6,316 | 437 | 112,630 |
| 7 | 2,927 | 1,515 | 1,267 | 55,150 | 2,200 | 613 | 543 | 20,386 |
| 8 | 697 | 256 | 702 | 27,973 | 191 | 30 | 203 | 9,222 |
| 9 | 4,217 | 921 | 1,354 | 34,576 | 2,356 | 612 | 526 | 26,381 |
| 10 | 2,453 | 503 | 664 | 28,018 | 1,673 | 282 | 433 | 15,538 |
| 11 | 10,725 | 2,965 | 4,811 | 80,579 | 5,489 | 1,353 | 6,680 | 47,714 |
| 12 | 4,804 | 808 | 404 | 12,238 | 1,795 | 356 | 375 | 10,175 |
| 13 | 5,011 | 676 | 60 | 18,395 | 2,179 | 473 | 10 | 11,170 |
| 14 | 4,673 | 2,024 | 329 | 33,039 | 5,105 | 1,735 | 650 | 20,134 |
| 15 | 15,444 | 4,059 | 1,599 | 89,125 | 9,207 | 2,413 | 736 | 38,216 |
| 16 | 4,157 | 822 | 424 | 45,479 | 1,799 | 631 | 432 | 10,639 |
| 17 | 13,052 | 841 | 175 | 20,565 | 4,415 | 496 | 52 | 15,492 |
| 18 | 3,790 | 107 | 0 | 11,125 | 1,238 | 52 | 6 | 9,350 |
| 19 | 3,271 | 313 | 50 | 32,200 | 1,834 | 77 | 162 | 11,285 |
| 20 | 8,254 | 1,658 | 466 | 39,170 | 7,778 | 1,441 | 1,000 | 39,620 |
| 21 | 11,260 | 2,617 | 0 | 24,116 | 16,307 | 2,868 | 1,310 | 55,932 |
| 22 | 5,007 | 1,136 | 0 | 21,397 | 9,723 | 1,561 | 273 | 46,648 |
| 23 | 4,802 | 1,200 | 424 | 22,398 | 2,128 | 750 | 0 | 26,071 |
| 24 | 11,542 | 3,796 | 2,530 | 59,501 | 11,312 | 2,709 | 274 | 54,695 |
| 25 | 532 | 225 | 0 | 3,616 | 3,304 | 456 | 29 | 15,189 |
| 26 | 4,840 | 1,743 | 1,479 | 46,094 | 2,979 | 1,363 | 2,449 | 33,878 |
| 27 | 2,791 | 846 | 794 | 51,145 | 1,151 | 436 | 622 | 17,532 |
| 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | 2,086 | 19 | 186 | 3,974 | 3,138 | 86 | 145 | 8,894 |
| 30 | 85 | 0 | 10 | 102 | 209 | 0 | 19 | 445 |
| 31 | 806 | 28 | 84 | 697 | 841 | 1 | 67 | 2,812 |
| 32 | 733 | 0 | 1,024 | 3,816 | 1,945 | 98 | 1,997 | 9,820 |
| 33 | 1,034 | 155 | 392 | 18,295 | 1,527 | 40 | 321 | 20,258 |
| 34 | 444 | 0 | 19 | 552 | 256 | 0 | 15 | 1,467 |
| 35 | 184 | 17 | 83 | 1,796 | 216 | 0 | 81 | 2,098 |
| 36 | 51 | 4 | 27 | 219 | 121 | 0 | 19 | 4,182 |
| 37 | 20 | 0 | 51 | 0 | 212 | 45 | 399 | 170 |
| 38 | 274 | 29 | 76 | 840 | 118 | 0 | 25 | 775 |

Table 6.3-4 Peak Hour Trip Generation and Attraction by Modes in 2005

| Zone | Generation | | | | Attraction | | | |
|---|---|---|---|---|---|---|---|---|
| | Car | Taxi | Truck | Bus | Car | Taxi | Truck | Bus |
| 1 | 3,180 | 173 | 107 | 10,019 | 4,762 | 86 | 126 | 26,311 |
| 2 | 13,031 | 473 | 610 | 27,547 | 6,277 | 649 | 35 | 20,765 |
| 3 | 13,419 | 897 | 0 | 16,623 | 11,166 | 2,136 | 453 | 34,147 |
| 4 | 13,342 | 1,605 | 374 | 12,240 | 17,250 | 2,623 | 348 | 50,261 |
| 5 | 6,760 | 1,001 | 0 | 13,870 | 17,703 | 3,279 | 5 | 71,402 |
| 6 | 4,812 | 2,039 | 975 | 25,726 | 31,212 | 8,037 | 656 | 132,224 |
| 7 | 3,206 | 1,601 | 1,264 | 59,355 | 2,320 | 623 | 456 | 21,993 |
| 8 | 792 | 302 | 803 | 30,492 | 236 | 37 | 254 | 10,068 |
| 9 | 4,897 | 1,047 | 1,265 | 36,661 | 2,797 | 681 | 627 | 28,440 |
| 10 | 2,883 | 566 | 791 | 38,764 | 1,940 | 305 | 571 | 20,235 |
| 11 | 12,593 | 3,264 | 5,854 | 105,021 | 6,353 | 1,559 | 7,409 | 60,233 |
| 12 | 6,589 | 1,007 | 627 | 15,007 | 2,210 | 459 | 617 | 12,131 |
| 13 | 5,800 | 782 | 40 | 20,711 | 2,580 | 546 | 19 | 12,571 |
| 14 | 5,673 | 3,133 | 361 | 36,305 | 6,168 | 1,920 | 900 | 22,942 |
| 15 | 18,007 | 4,750 | 1,642 | 95,461 | 10,759 | 2,703 | 868 | 40,732 |
| 16 | 5,100 | 909 | 518 | 49,855 | 2,171 | 751 | 525 | 12,018 |
| 17 | 14,724 | 1,032 | 181 | 22,318 | 5,138 | 593 | 55 | 16,684 |
| 18 | 6,728 | 207 | 0 | 15,274 | 2,438 | 67 | 24 | 13,078 |
| 19 | 4,628 | 405 | 28 | 36,237 | 2,340 | 95 | 306 | 12,591 |
| 20 | 9,475 | 1,889 | 623 | 43,219 | 9,315 | 1,818 | 1,166 | 43,801 |
| 21 | 12,944 | 3,172 | 0 | 29,887 | 19,914 | 3,426 | 1,397 | 66,453 |
| 22 | 6,002 | 1,252 | 0 | 24,794 | 11,034 | 1,813 | 303 | 56,177 |
| 23 | 5,625 | 1,413 | 372 | 27,669 | 2,529 | 801 | 0 | 29,360 |
| 24 | 13,447 | 4,436 | 2,669 | 71,429 | 12,845 | 2,966 | 356 | 67,319 |
| 25 | 593 | 247 | 0 | 4,607 | 3,684 | 538 | 56 | 17,968 |
| 26 | 5,543 | 1,878 | 1,662 | 49,458 | 3,318 | 1,490 | 2,629 | 36,049 |
| 27 | 3,418 | 986 | 1,195 | 57,259 | 1,364 | 503 | 941 | 19,677 |
| 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | 3,186 | 31 | 414 | 6,504 | 4,702 | 112 | 252 | 11,117 |
| 30 | 106 | 0 | 11 | 85 | 224 | 0 | 21 | 532 |
| 31 | 1,205 | 48 | 133 | 747 | 1,202 | 2 | 55 | 3,477 |
| 32 | 1,206 | 0 | 1,592 | 5,690 | 2,582 | 102 | 2,606 | 12,340 |
| 33 | 1,346 | 233 | 762 | 26,984 | 1,900 | 44 | 450 | 28,884 |
| 34 | 552 | 0 | 40 | 612 | 316 | 0 | 12 | 1,346 |
| 35 | 315 | 8 | 91 | 3,455 | 360 | 0 | 131 | 2,638 |
| 36 | 65 | 2 | 16 | 301 | 156 | 0 | 12 | 5,126 |
| 37 | 28 | 0 | 62 | 0 | 283 | 46 | 472 | 217 |
| 38 | 503 | 22 | 71 | 2,051 | 175 | 0 | 40 | 930 |

(unit: Person Trips/hour)

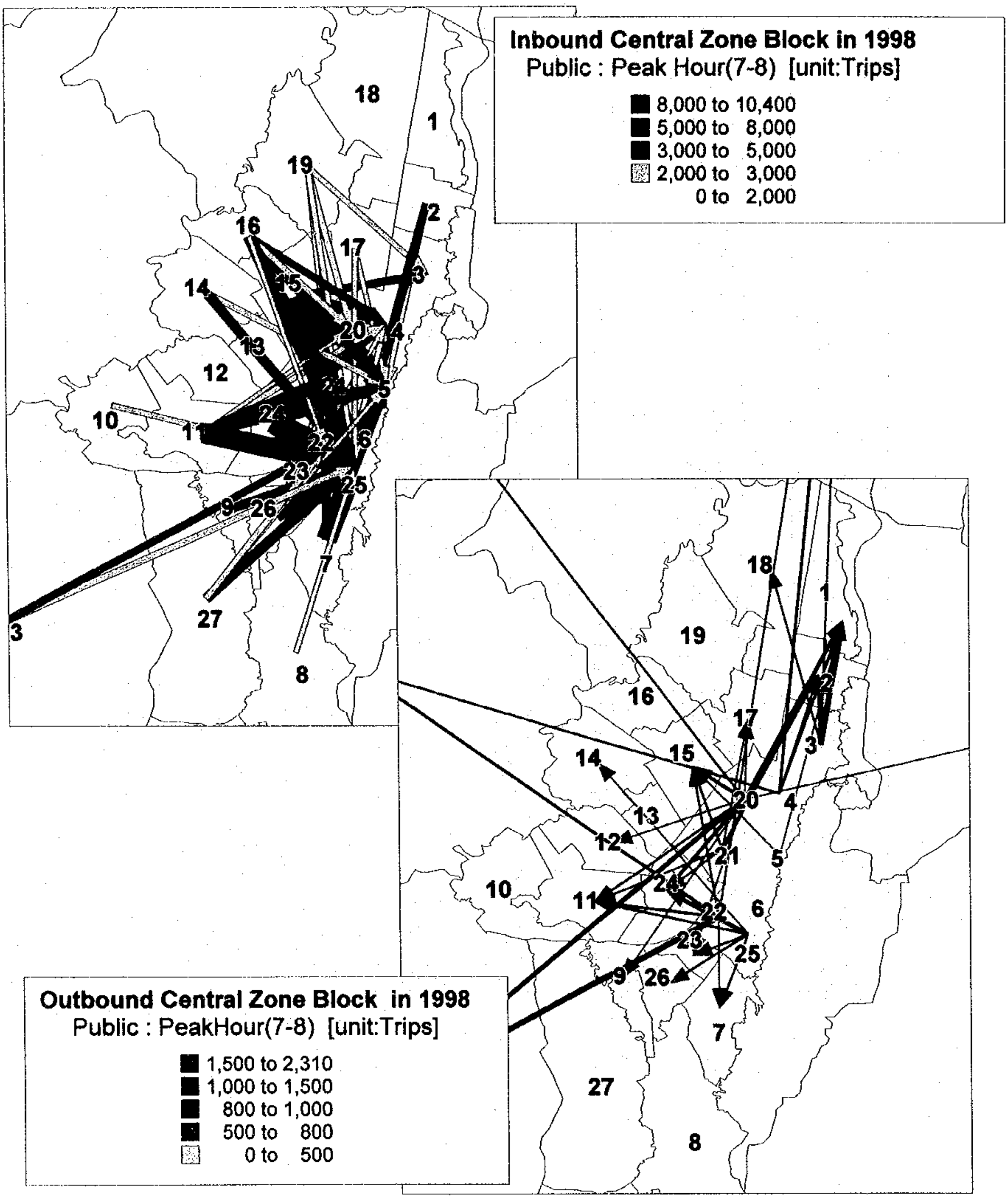



Figure 6.3-3 Peak Hour Trip Desire Lines by Public Mode in 1998

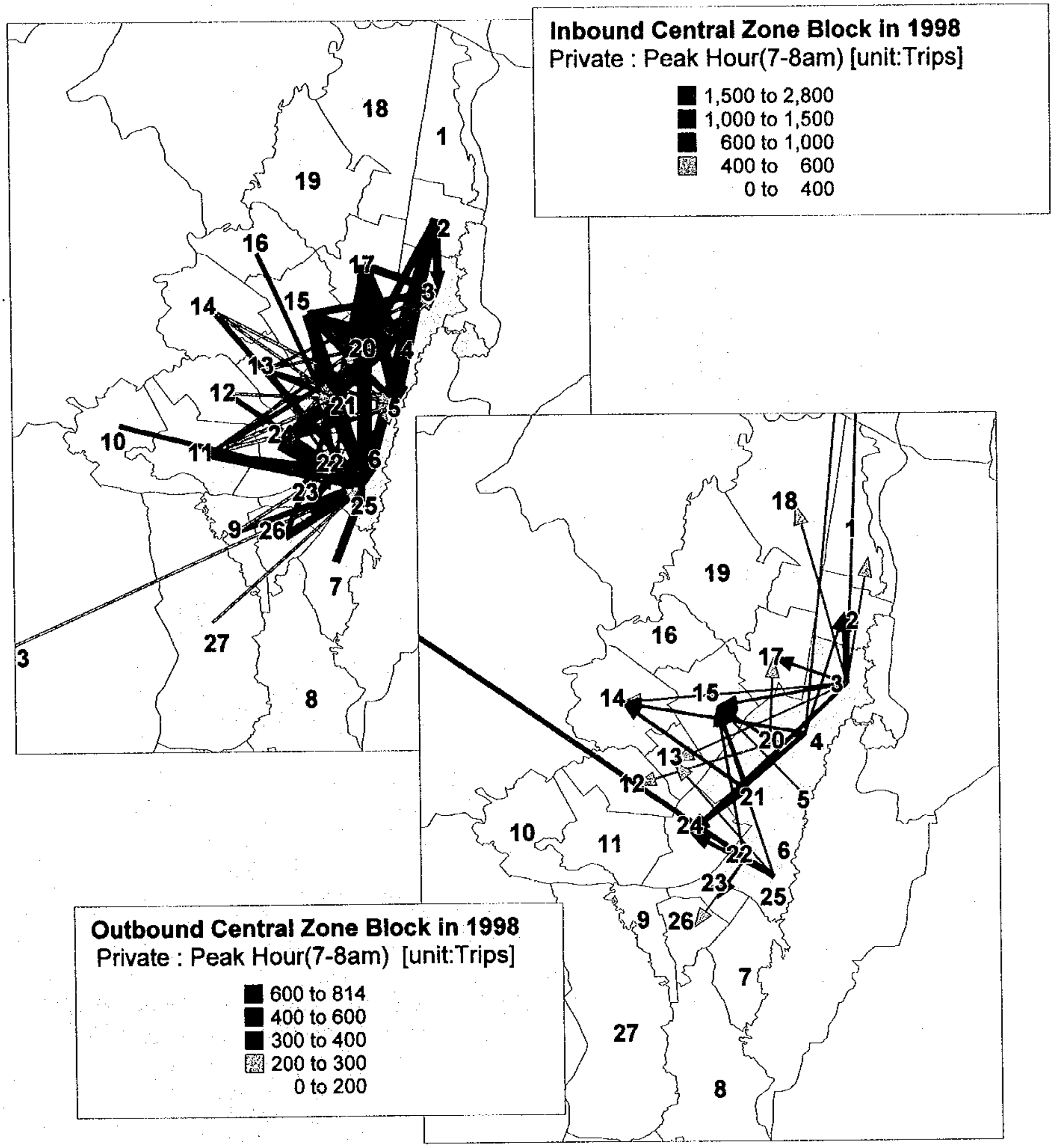



Figure 6.3-4 Peak Hour Trip Desire Lines by Private Mode in 1998

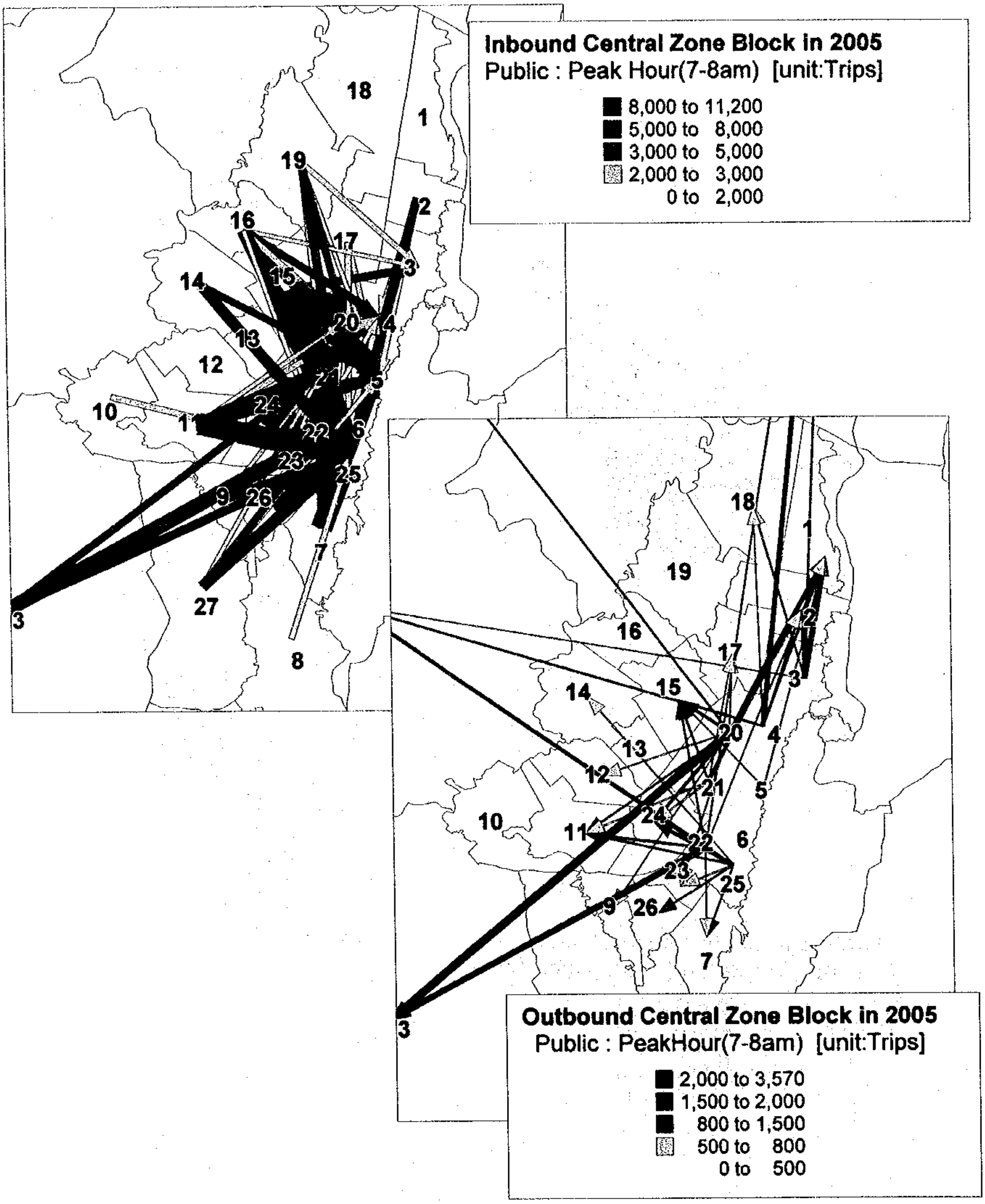



Figure 6.3-5 Peak Hour Trip Desire Lines by Public Mode in 2005

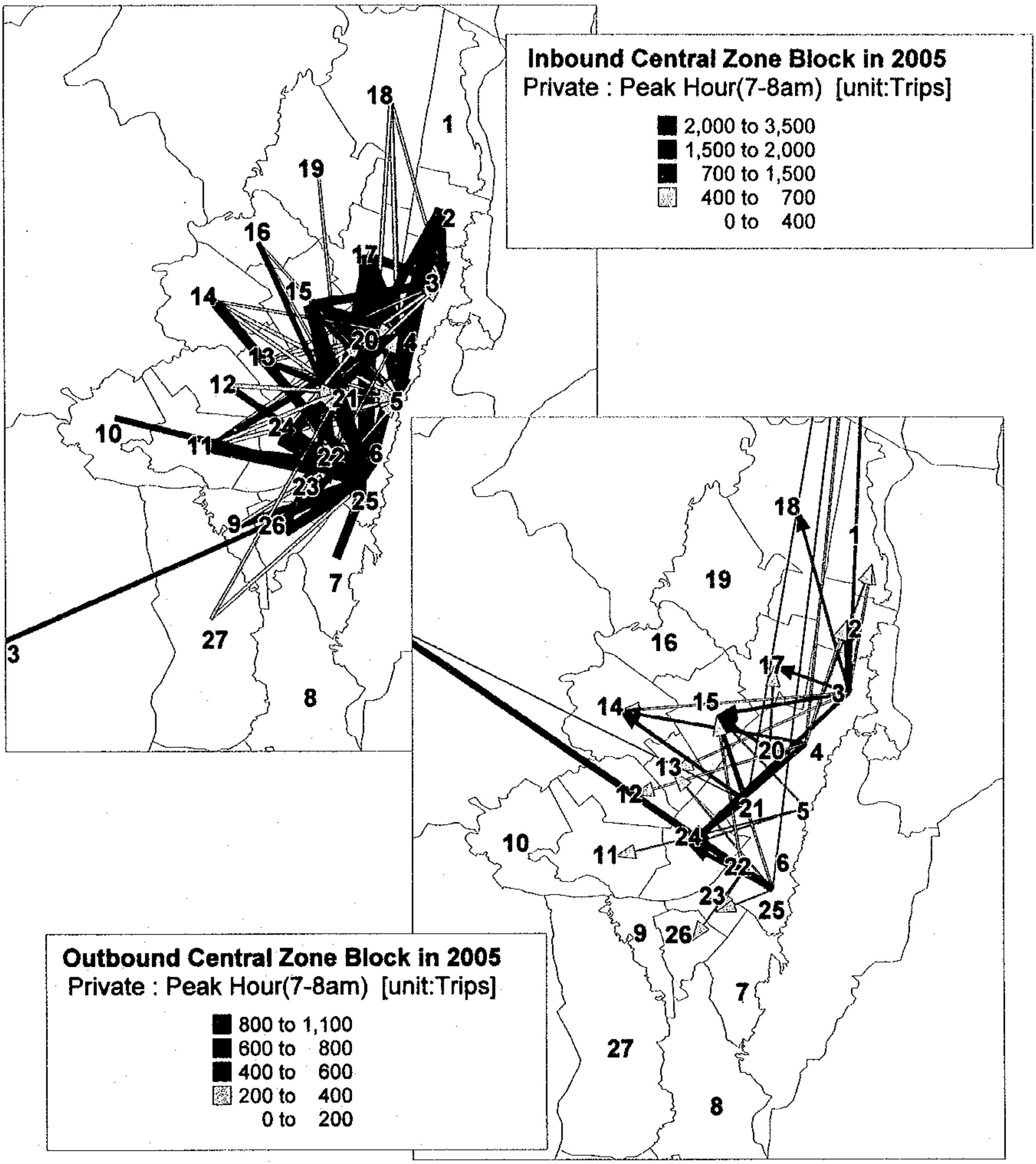



Figure 6.3-6 Peak Hour Trip Desire Lines by Private Mode in 2005

# CHAPTER 7
# Conceptual Study of Trunk Bus System

# 7. CONCEPTUAL STUDY OF TRUNK BUS SYSTEM

## 7.1. GENERAL

In this Chapter 7, the preliminary development plan of trunk busway system is made based on the proposed conceptual plan. The development plan is examined for operation system. The several alternative plans for the development plan are made and evaluated by the transit assignment simulation model in Chapter 8. The alternative plans are composed of the following:

- Trunk and feeder bus route alternatives
- Bus fleet system
- Tariff system

The development plan of the trunk bus system in consideration of a project life of 10 years are evaluated on the following conditions:

1) In the year 2000 as a middle-term: Network of three (3) trunk busways is developed: Av. Caracas-Autopista Norte, Av. 80 and Corredor Ferreo, which are planned by IDU.

2) By the year 2005 as a target year: Network of eleven (11) trunk busways is completed and trunk and feeder bus operation is commenced.

## 7.2. CALIBRATION

In order to evaluate the alternative plans to be proposed in the trunk bus system, a bus transit assignment model is used. The transit model named STRADA is developed by JICA. Before the evaluation is conducted, a calibration of the transit model is carried out.

In order to validate the present operation system by the transit model, the bus transit assignment is carried out by using bus routes on the present operation system and peak hour bus passenger OD trip table. The present bus route network is integrated into approximately 150 routes from 860 routes to accurately reproduce actual bus flow conditions and to make it easier to handle the data. Bus route data with a similar route is integrated under the same rule. Figure 7.2-3 shows the number of bus service frequencies for the integrated bus routes on roads. In this figure, the number of integrated frequencies is drawn by a width line which is proportional to the number of bus frequencies.

Comparing integrated bus routes to actual bus routes is shown in Figure 7.2-4. It appears that both bus frequencies on roads are more or less similar.

Figure 7.2-1 and Figure 7.2-2 show comparison between actual bus service frequency (inputted frequency) and estimated frequency by roads and bus route, respectively. This service frequency means bus flows on roads. These figures: actual frequency and the estimated, are in the ratio of 1:1 on the scatter gram in the graph. Figure 7.2-5shows the comparison between the inputted and estimated frequency on the road network. The results of validation for operation are sufficiently satisfactory.

Figure 7.2-6 shows assigned bus passenger flows on roads in the whole city of Bogota. It is seen that the heavy bus passenger flows show on major roads: Caracas, Av. 10, Av. Quito, Av. 68, Calle 80, etc.

The number of transfers at bus stops is also estimated by the transit model. The ratio of non-transfer to the total is approximately 71%, and the ratio for one (1) time transfer is

27%. The balance (two transfer) is 2%. Those figures are remarkably close to the result of interview survey which shows at 79% for non-transfer.

Number of bus passengers who board, alight and transfer at bus stops is also validate as shown in Figure 7.2-7. The right side figure enlarges the central commercial areas. In this figure, the total numbers of boarding, alighting and transferring are represented by a pie chart whose diameter is in proportion to the total number of passengers. However, those estimated figures at bus stops or terminals are integrated into network node in the assignment model. Major locations for origin, destination and transfer can be indicated from this figure. The busy locations where many bus passengers board, alight and transfer are on the same roads as those for heavy bus flows, and are concentrated in the central commercial areas. This information is available for facility plan of bus stops and terminals.

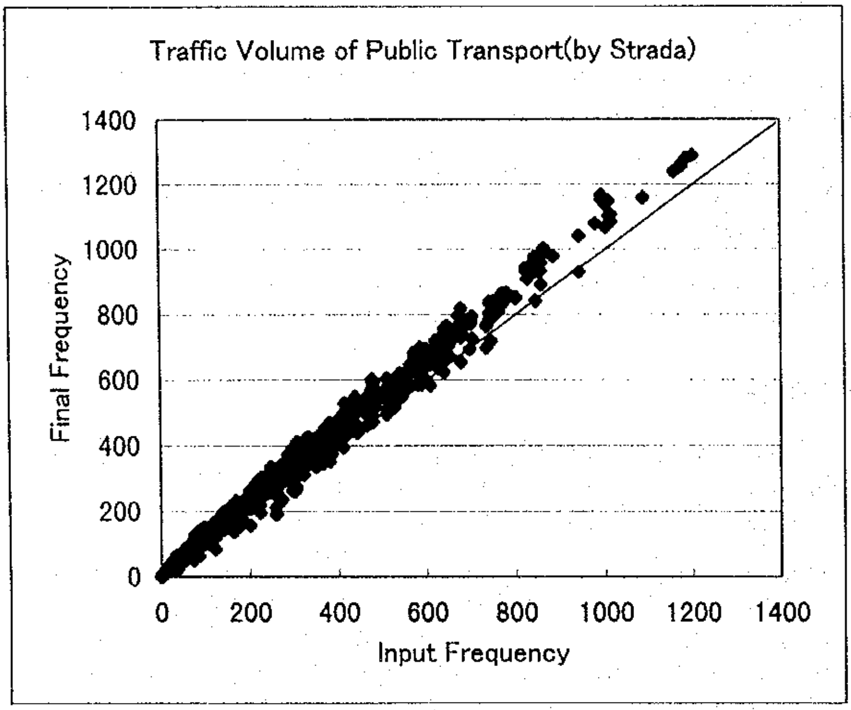



Figure 7.2-1 Comparison between Actual Bus Frequency and Estimated Frequency by Roads

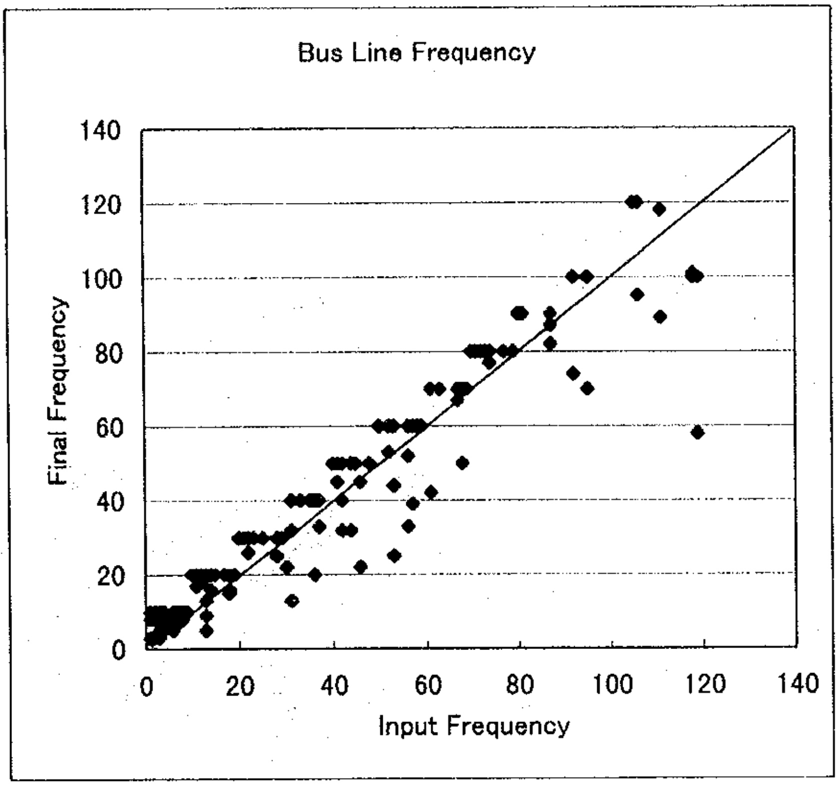



Figure 7.2-2 Comparison between Actual Bus Frequency and Estimated Frequency by Route

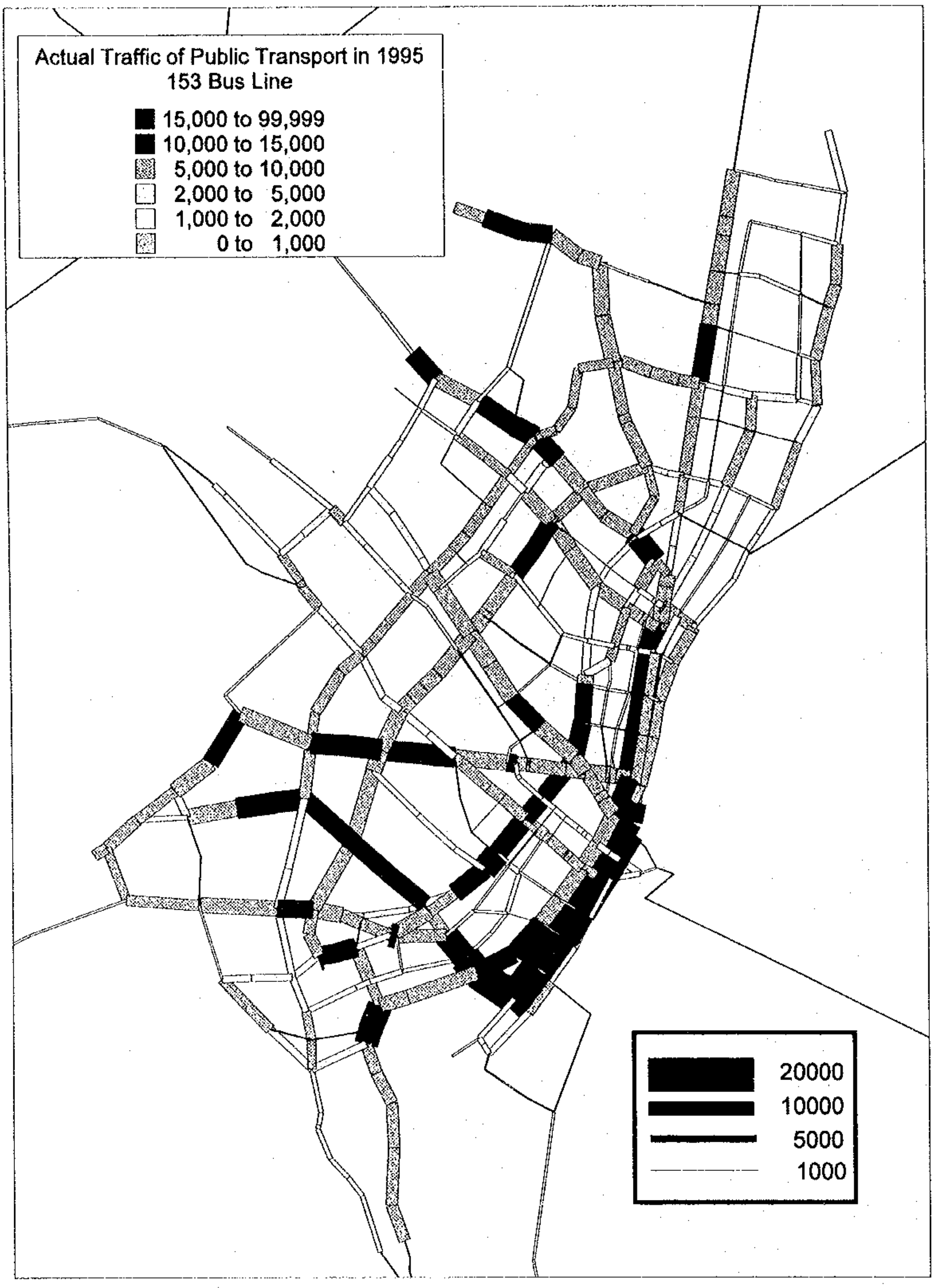



Figure 7.2-3 Total Number of Bus Service Frequencies for Integrated Bus Routes on Roads

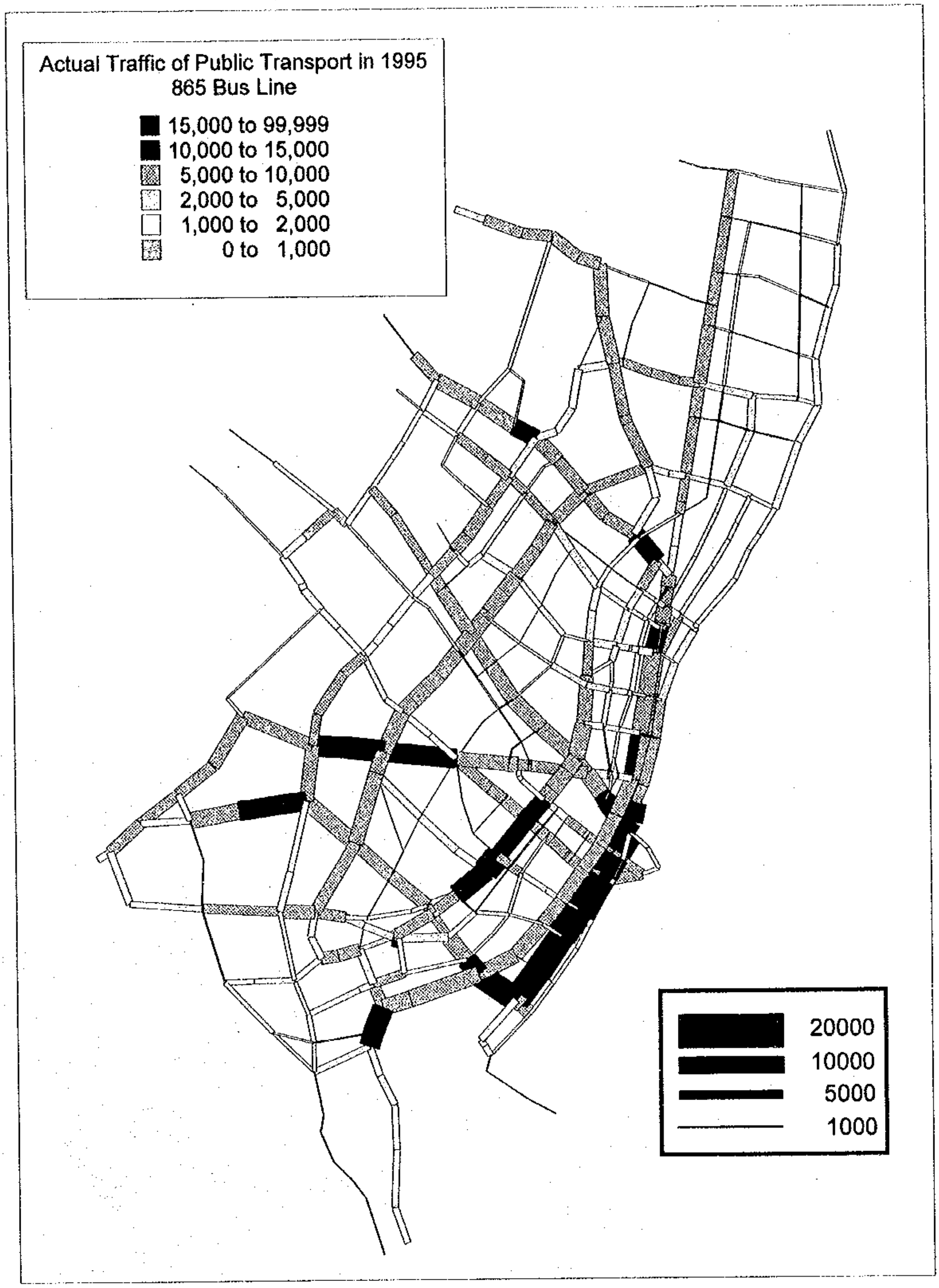



Figure 7.2-4 Total Number of Bus Service Frequencies for 865 Bus routes on Roads

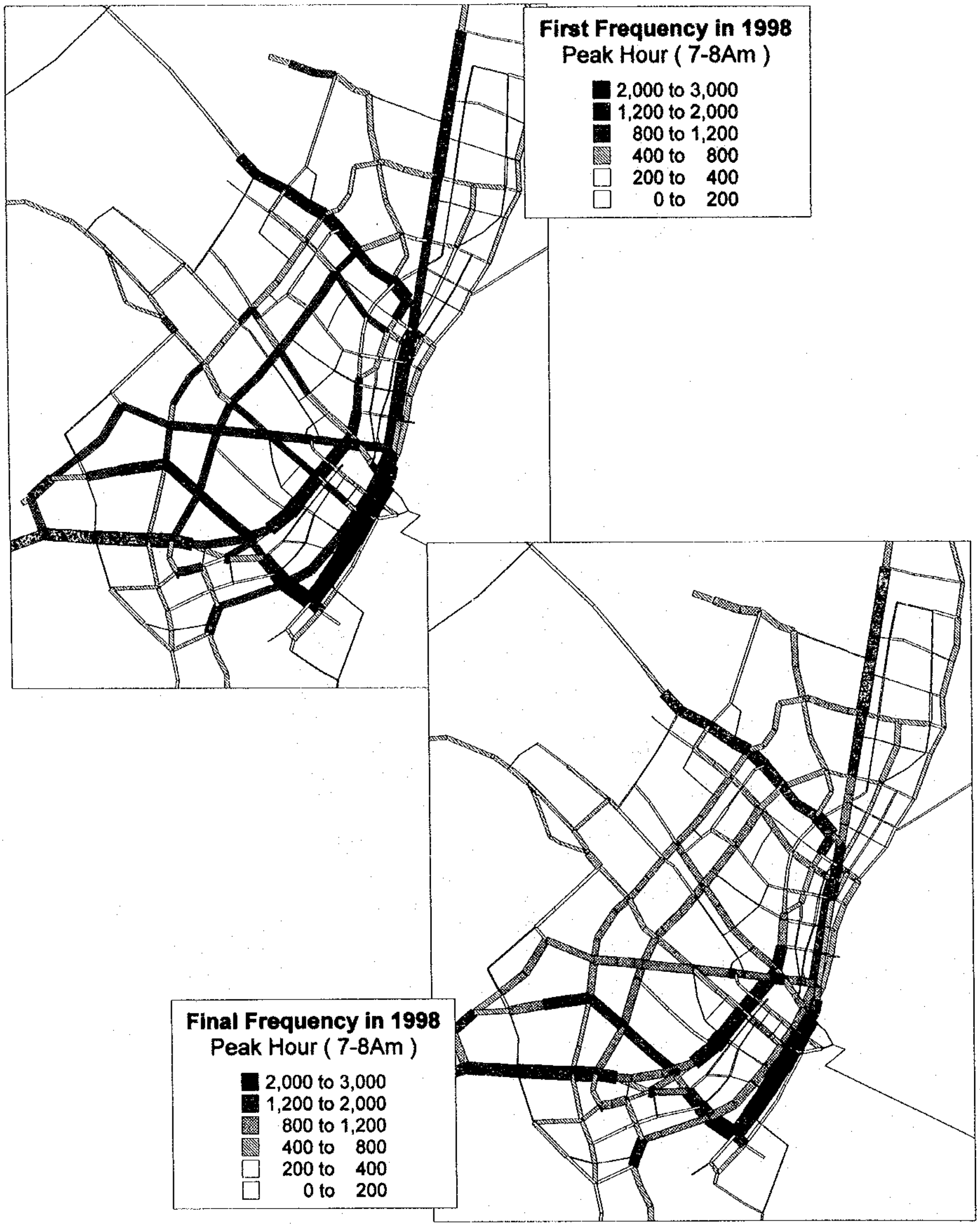



Figure 7.2-5 Comparison between Inputted and Estimated Frequencies on Roads

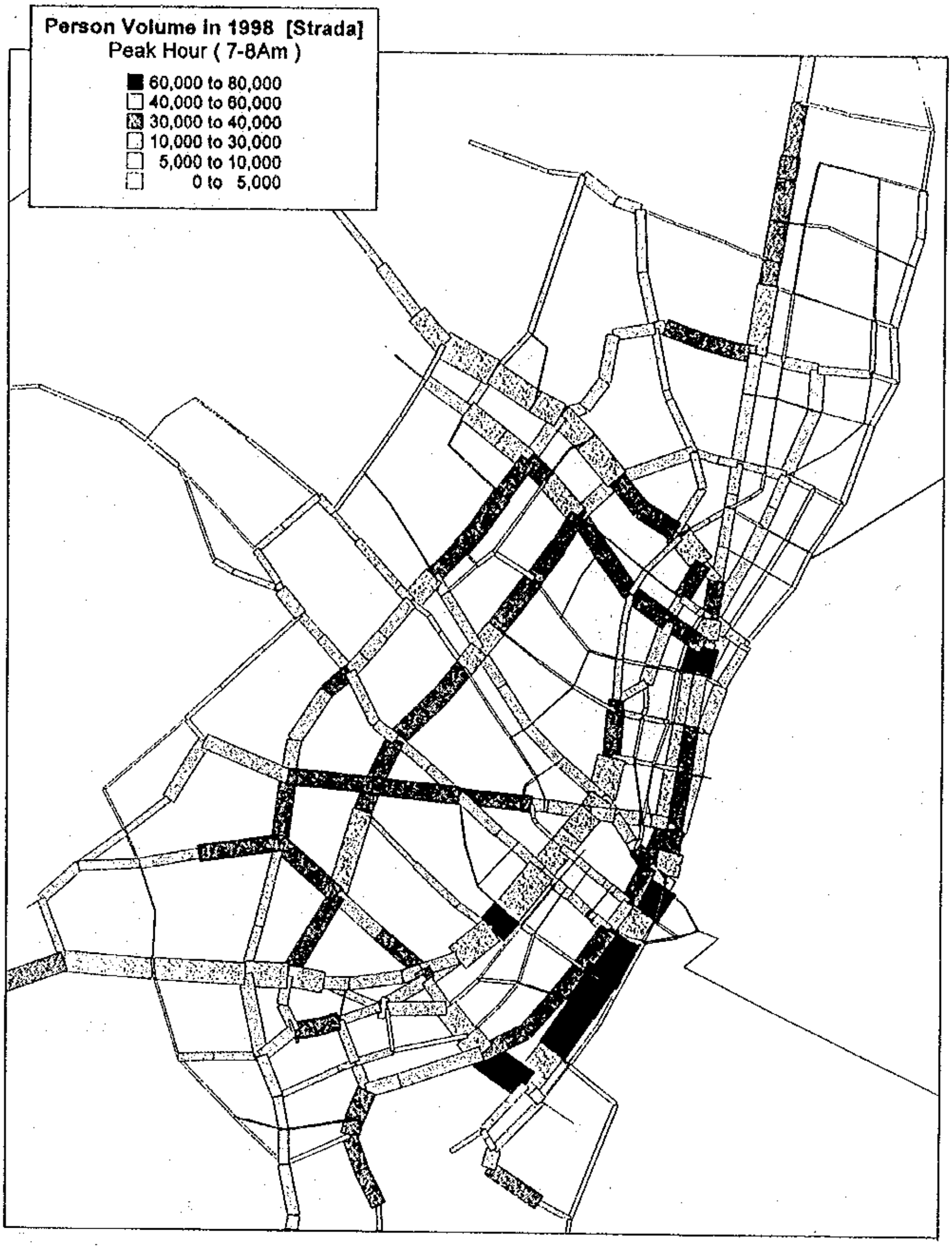



Figure 7.2-6 Assigned Bus Passenger Flows by Bus Transit Assignment

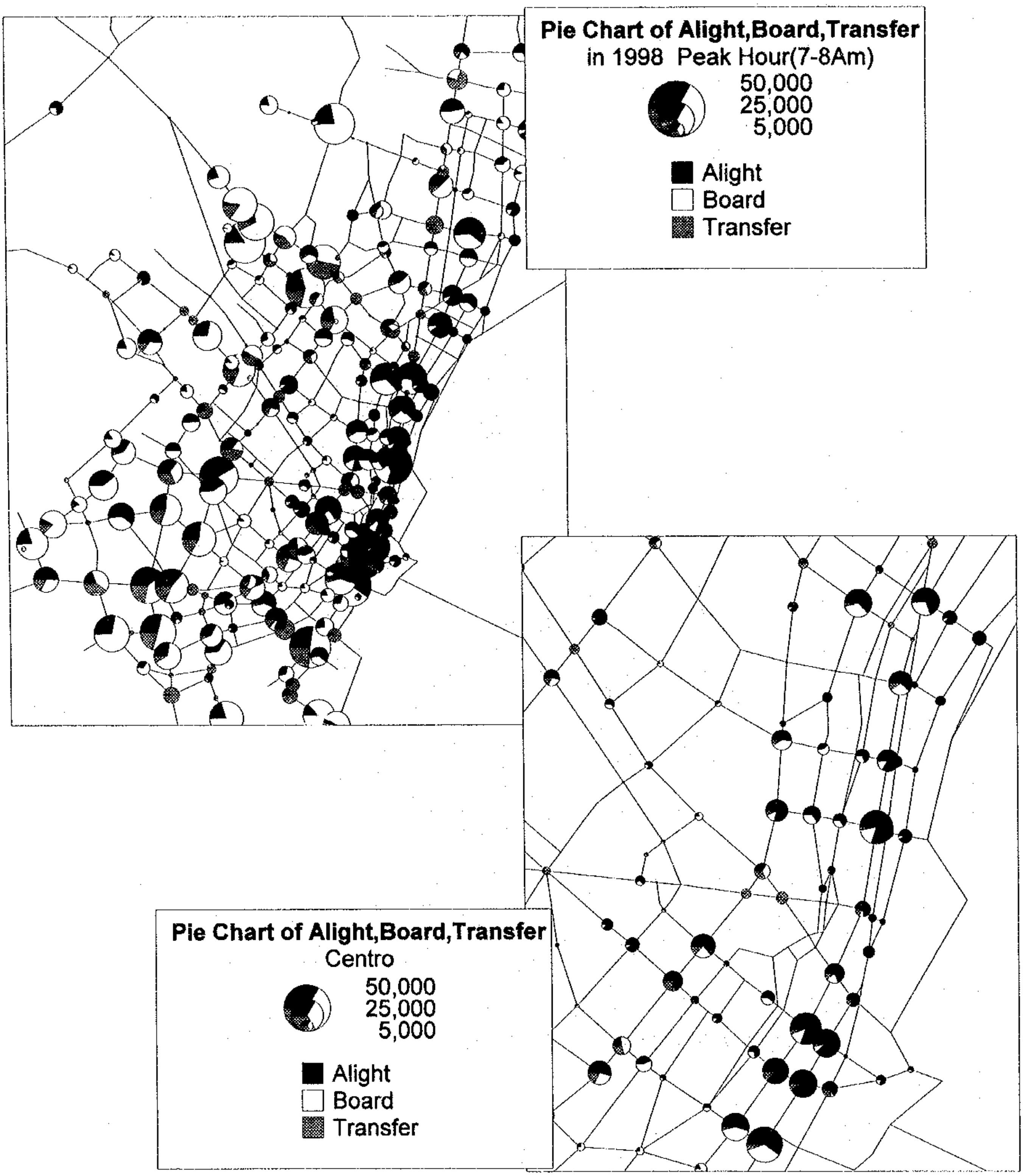



Figure 7.2-7 Estimated Bus Alighting, Boarding and Transfer Volumes by Location

## 7.3. CONCEPTUAL PLAN OF TRUNK BUS SYSTEM

### 7.3.1. TRUNK AND FEEDER BUS SYSTEM

As for preliminary development planning for trunk and feeder bus system, the most important element is probably the degree of segregation between buses and other traffic. The other critical components of a busway transit system are bus running section, bus stop and intersection. In general, measured peak hour passenger flows range from 20,000 to 25,000 passenger/ hour/ direction on trunk and feeder system, in contrast to 30,000 on Caracas.

In many cases, the capacity constraint on a system will be the bus stop. It depends on the number of bus bays provided, facilities for buses to overtake one another, etc. Intersections influence the flow of buses along at-grade busways and consequently affect both capacity and speed of bus operation. A particularly busy intersection may be the busway bottleneck. The capacity of intersections and bus stop without overtaking facility may influence bus flows. In most cases, however, intersection capacity will be greater than that of the most critical bus stop.

Therefore, the preliminary development plan is made taking into account above critical points, simultaneously with the planning for bus route and its frequency system.

### 7.3.2. TRUNK BUSWAY NETWORK

#### (1) Related Development Plan

There are many existing urban transport projects in Bogota such as the SITM's mass transit railway project, Transmilenio project for public transport and the road construction and improvement projects as mentioned in Section 5.4.3. Among those projects, the following public transport projects are incorporated into the public transport network data as a related development plan:

- SITM's railway project
- Transmilenio project

##### *1) SITM's Railway Project*

The plan of First Metro Line Project proposed by the SITM study is divided into two (2 ) stages:

- The first stage is constructed with a length of 15.34 km from Tintalito terminal yard to the San Martin station. The construction period will take approximately 5 years (1999 to 2003).
- The second stage is planned from the San Martin station to Puerto Amor terminal with a length of 14 km over a six (6) years period beginning in 2002.

The following information is inputted in the public transport network:

- In the year 2005: stage 1 completed
- In the year 2010: stage 2 completed

##### *2) Transmilenio Project by STT*

The Transmilenio project proposes the introduction of trunk busways on major roads with the new operation system such as trunk and feeder bus route, big sized buses, a simple and integrated bus stop, etc. The development stages of the project are as follows:

Stage 1998 to 2000

The four (4) busways on the following road corridors will be constructed:

- Autopista Norte (Calle 80 to Calle 170)
- Av. Caracas (Molinos to Calle 80)
- Calle 80 (Caracas to Rio Bogota)
- Corredor Ferreo del Sur which changes to the Stage 1 in the First Metro Line in 2005 and certain section between Av. Cra. 68 and boundary of the city changes to bus feeder line.

Stage 2001 to 2004

The four (4) busways on the following road corridors will be constructed:

- Av. de las Americas (Cra. 30 to Mosquera Limit)
- Av. Suba (Cra. 30 to Subazar)
- Av. Cra. 68 (Venecia to Autopista Norte)
- Av. Boyaca (Autopista del Sur to Calle 127)

Stage 2004 to 2007

The four (4) busways and one (1) railway on the following road corridors will be constructed:

- First Metro Line by SITM
- Av. Boyaca to Autopista to Ilano until Juan Rey
- Av. San Jose to Calle 170 (Cra. 7 to Av. Boyaca)
- Troncal Juan Rey (Calle 1 to Juan Rey)
- Av. Ciudad de Cali (Autosur to Calle 170)

### (2) Project Stage of Busway in the Development Plan

Project stages of development plan for trunk bus system in the Study are shown as follows:

#### *1) Stage 1 (in 2000)*

The following three segregated busways for trunk bus system are planned:

- Av. Caracas - Autopista Norte (proposed Transmilenio and Study road)
- Calle 80 (proposed Transmilenio)
- Corredor Ferreo del Sur (proposed Transmilenio)

#### *2) Stage 2 (in 2005)*

The following 8 projects are planned to be added to the eleven (11) busways.

- Cra. 7a-Cra.10
- Av. Ciudad de Quito
- Av. Cra. 68-Av.100
- Calle 170

- Av. Suba
- Av. Boyaca
- Av. Centenario
- Av. de las Americas

Those Study roads are shown in Figure 7.3-1.

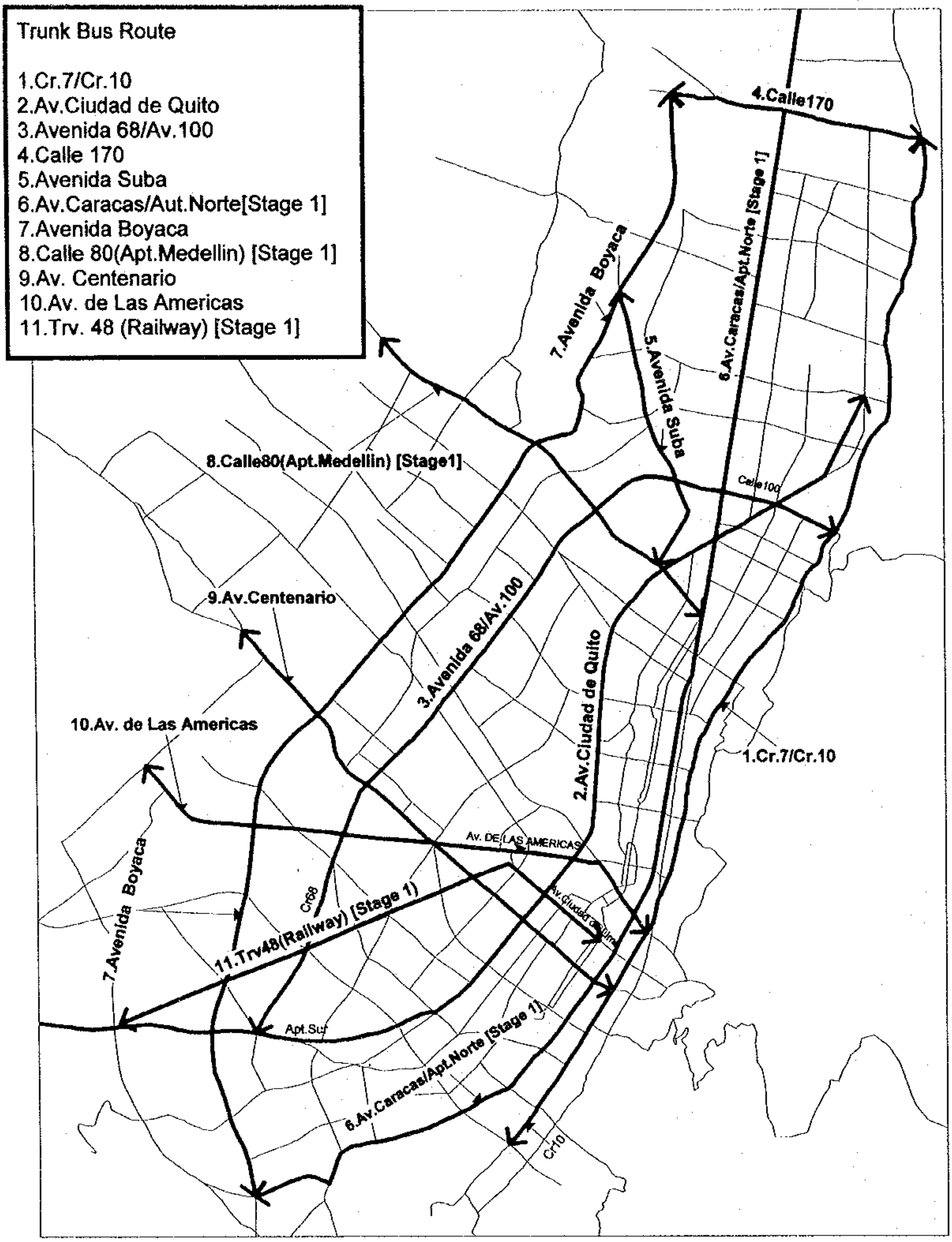



Figure 7.3-1 Development Plan of Trunk Busway

### 7.3.3. BUS ROUTE ALTERNATIVES

Bus route configuration is composed of bus route network linked between one main central bus terminal and several peri-terminals on the conceptual plan. The central bus terminal where many bus passengers concentrate, has a function such as bus transfer and connecting point of many trunk bus routes where it is possible to flexibly select bus routes, while suburban bus terminals have a function of terminal in suburban areas and connect between trunk bus and feeder bus at suburban areas.

#### (1) Stage 1: in 2000

##### *1) Study Conditions*

The development plan of trunk busway is examined on the following conditions:

1) Busway: only three (3) fully segregated busways are constructed (see Section 7.3.2).
2) Trunk bus: the trunk bus is operated on the segregated busway.
3) Feeder bus: the feeder bus will not be in operation in 2000. This is because, in the year 2000, full trunk busway network with only 3 busways constructed will not be completed, and almost all the buses (ordinary bus) will still be operated on the the existing bus routes with existing bus system. Therefore, it is not necessary to operate the feeder buses.
4) Ordinary bus: as for the operation of ordinary buses, two alternatives are proposed: alternative-1 is the case where the ordinary bus is operated on the same system (route) as that at the present. Alternative-2 is the same case as that of alternative-1, but bus routes diverted to trunk busways will be abolished by degree of diversion. The ordinary buses will be operated outside of segregated busway on roads.
5) Central bus terminal: In the year 2000, no central bus terminal will be ready. Therefore, at that time, bus routes must take U-turns near Av. Jimenez due to non availability of bus parking space.
6) Suburban bus terminal: five (5) suburban bus terminals will be ready by 2000 for bus parking, bus turning, and boarding and alighting of passengers who are in residential areas within Bogota.

##### *2) Trunk Bus Route Alternatives*

Six (6) trunk bus routes are proposed as shown in Figure 7.3-2. Figure 7.3-3 shows the component of trunk bus routes. The route configuration is simple but U-turn route will be on the roads. The trunk bus routes only link between the central areas and residential areas in suburbs of Bogota. Those four bus routes make U-turns between Av. Lima and Av. Jimenez where segregated busway is not available. Several alternative routes are considered as a U-turn route. Recommended U-turn routes are selected by direction taking into account the following factors.

1) To avoid passing through narrow roads and not to conflict with other vehicles
2) To avoid traffic congested roads and keep punctuality
3) To avoid left-turn
4) To avoid concentration of bus routes on the same roads

Figure 7.3-4 and Figure 7.3-5 show the recommended U-turn routes between Av. Lima and Av. Jimenez, which are more reasonable in the traffic management. On the recommended routes, there are several intersections where left-turn is prohibited. In order to obtain higher bus performance, it is necessary to approve the left-turn and to set signal time with bus priority phase.

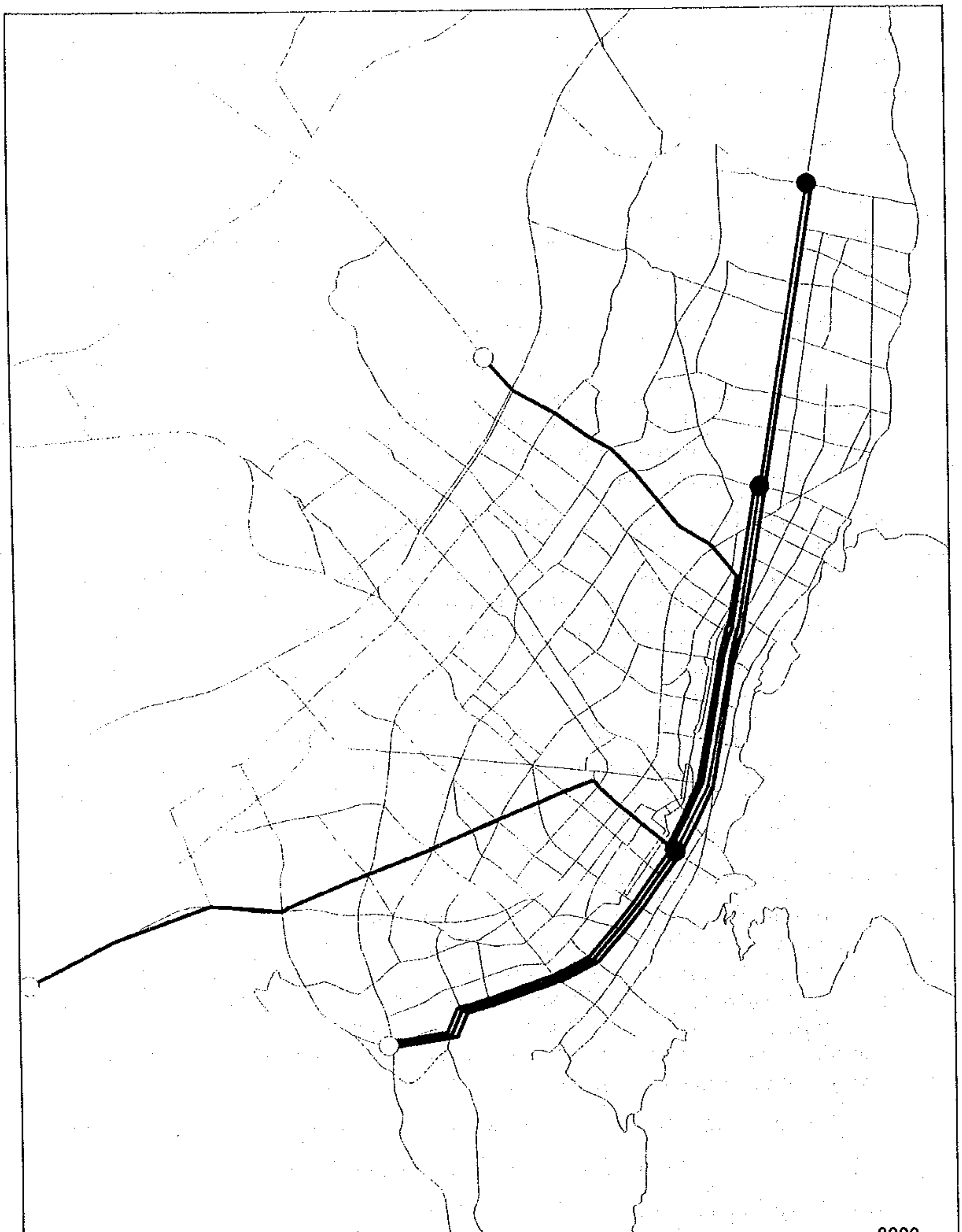



Figure 7.3-2 Trunk Bus Routes in 2000

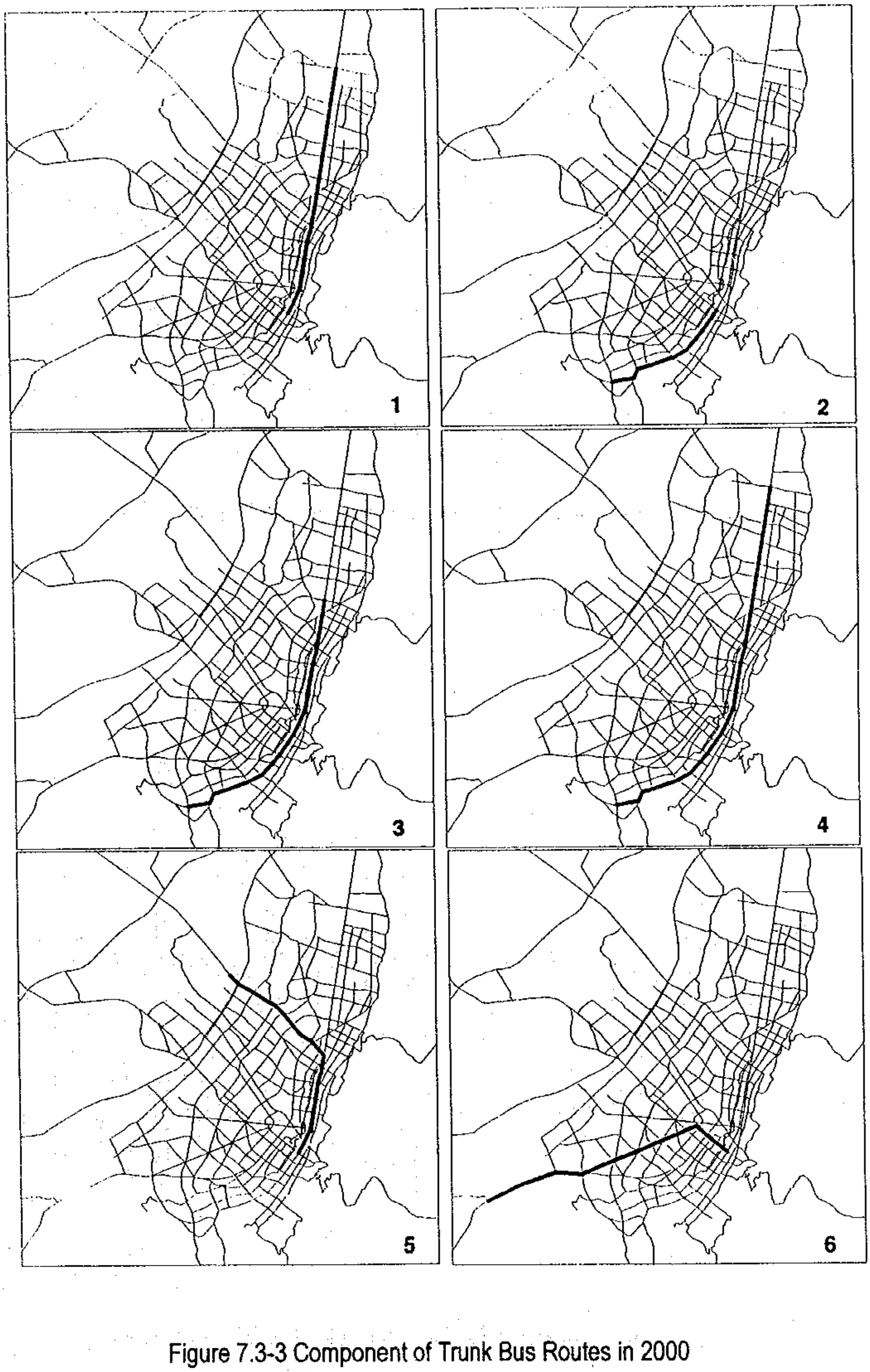



Figure 7.3-3 Component of Trunk Bus Routes in 2000

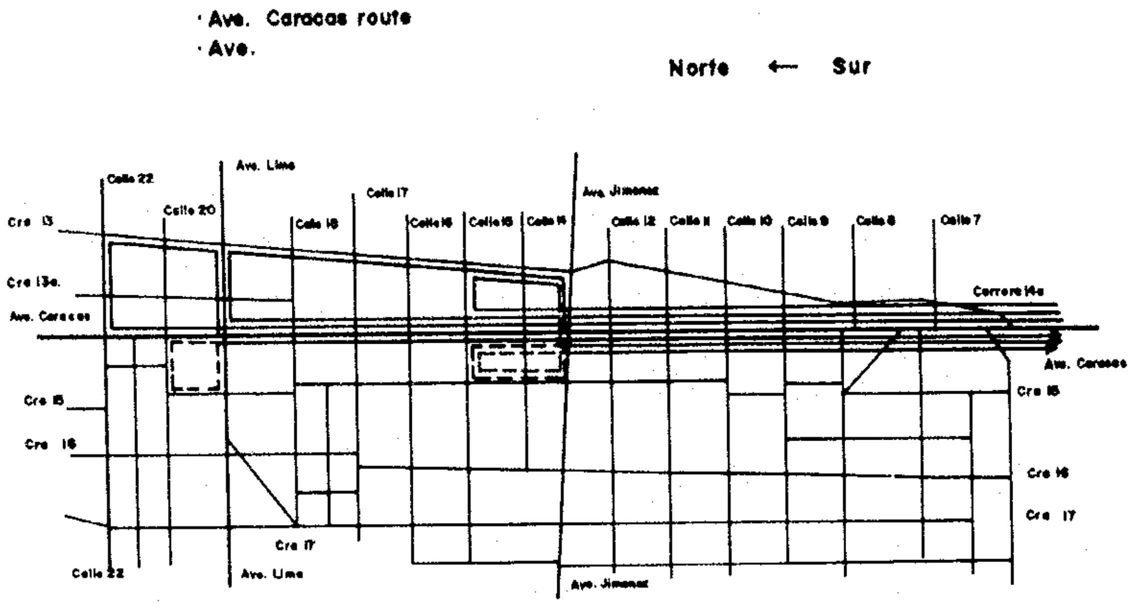



Figure 7.3-4 Recommended Bus U-turn Routes (South from/to Centro)

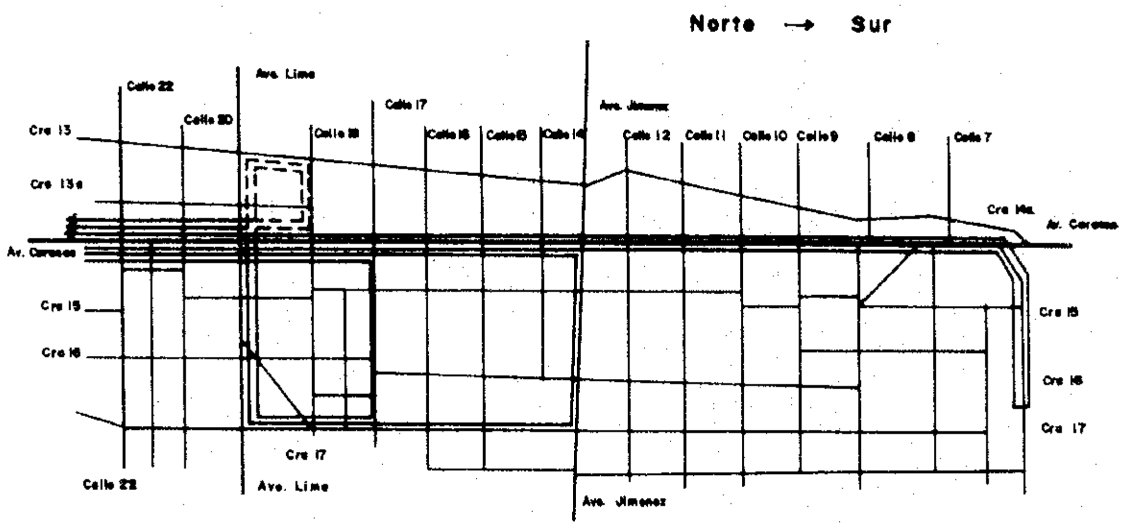



Figure 7.3-5 Recommended Bus U-Turn Routes (North from/to Centro)

## (2) Stage 2: in 2005

### *1) Study Conditions*

The development plan of trunk busway is examined on the following conditions:

1) Busway: eleven (11) fully segregated busways are completed (see Section 7.3.2).

2) Trunk bus: the trunk bus is operated on the segregated busway.

3) Feeder bus: since the trunk busway network will be completed by 2005, feeder bus will be operating to supplement a service of trunk bus within some areas where no trunk bus operate. The feeder buses are operated on roads without special bus priority measures.

4) Ordinary bus: the ordinary bus under present bus operation system will not be operating and existing bus routes basically will change to new trunk bus routes.

5) Central bus terminal: the central bus terminal will be completed by 2005 but some service facilities will not be sufficient. Therefore, the bus will be operated by bus route network linked between one main central bus terminal and several suburban bus terminals on the conceptual plan.

6) Suburban bus terminal: suburban terminals in the residential areas near the border of Bogota will be available for bus parking, bus turning, and boarding and alighting of passengers and will function as terminals for every trunk bus route.

### *2) Trunk Bus Route Alternatives*

By the 2005, the trunk bus route configuration is completed by links between the central bus terminal and suburban bus terminals. Two (2) route alternatives are proposed:

1) Alternative-1: a bus route network connecting only adjacent terminals with each other which refers to Alternative-A in the conceptual plan in Section 5.4.4.

2) Alternative-2: bus routes network which incorporate Alternative-A with Alternative-B in which bus route connects every bus terminal to each other as shown in Figure 5.4-5.

Figure 7.3-6 and Figure 7.3-9 show Alternative-1 and Alternative-2 of trunk bus routes in 2005, respectively. The components of each bus route by Alternatives are shown in Figure 7.3-7 and Figure 7.3-8 for Alternative-1, and Figure 7.3-10 to Figure 7.3-16 for Alternative-2.

Before examination of alternative routes, in order to know bus routes to be selected by bus passengers in 2005, traffic assignment was carried out by using input data which are peak hour bus passenger OD trip data in 2005 and existing road network.

Figure 7.3-17 to Figure 7.3-21 show the passenger link OD trips in the morning peak hour on selected bus routes in the planned eleven (11) busways. In those figures, the passenger movement between each pair of traffic zones is drawn by a line whose width is proportional to the number of trips between the zones. The selected sections of bus route are drawn by a line with a grid pattern, and the black lines with width line show the routes selected by bus passengers.

As can be seen, those figures show desire bus routes pass through the selected sections. The desire lines on Av. Suba connect between Suba areas and central commercial areas with stronger line. This indicates that persons who dwell in Suba desire to arrive to the central areas with one ride. Those figures are a good guide to make a trunk bus route and Alternatives-1 and –2 are made taking it into account.

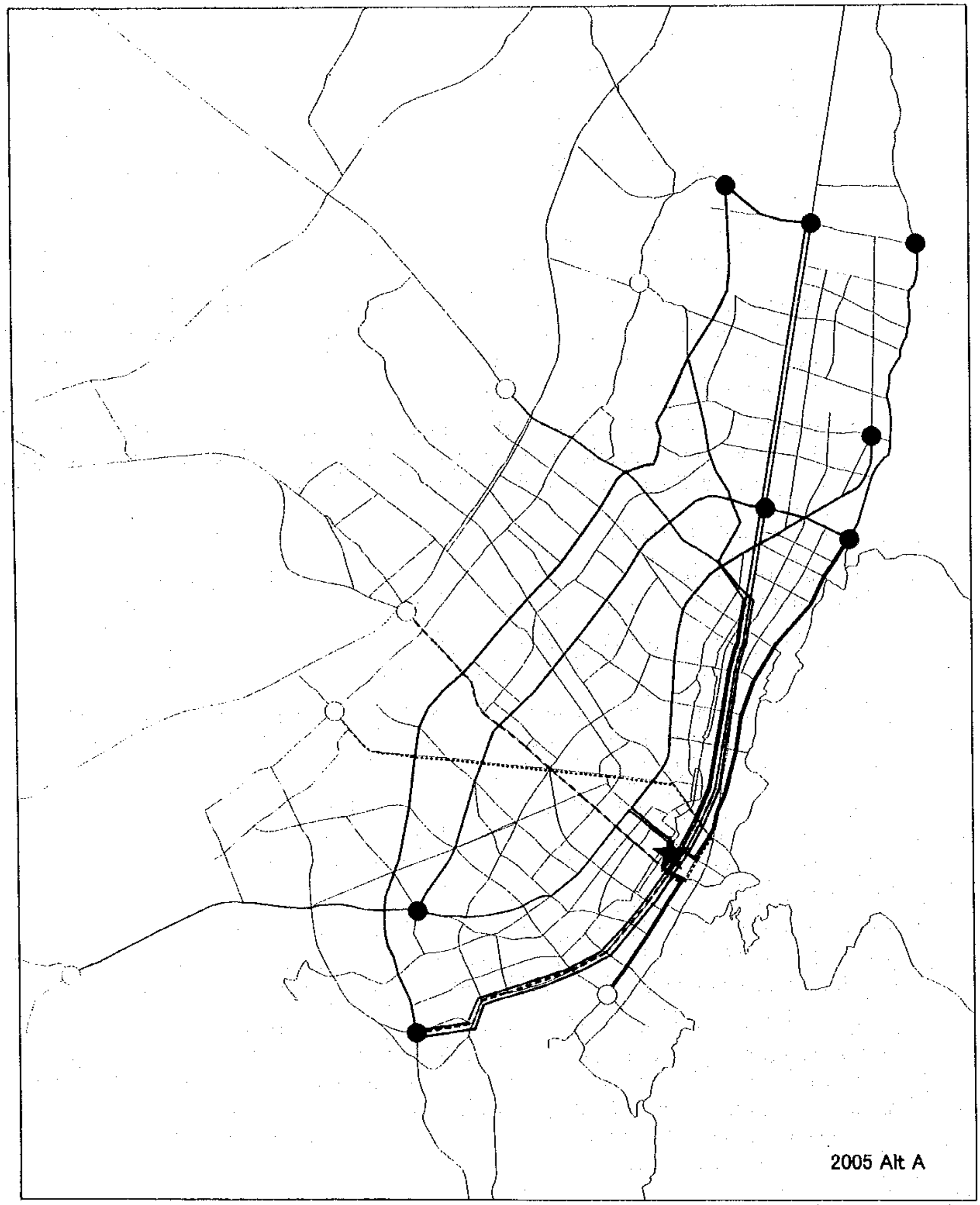
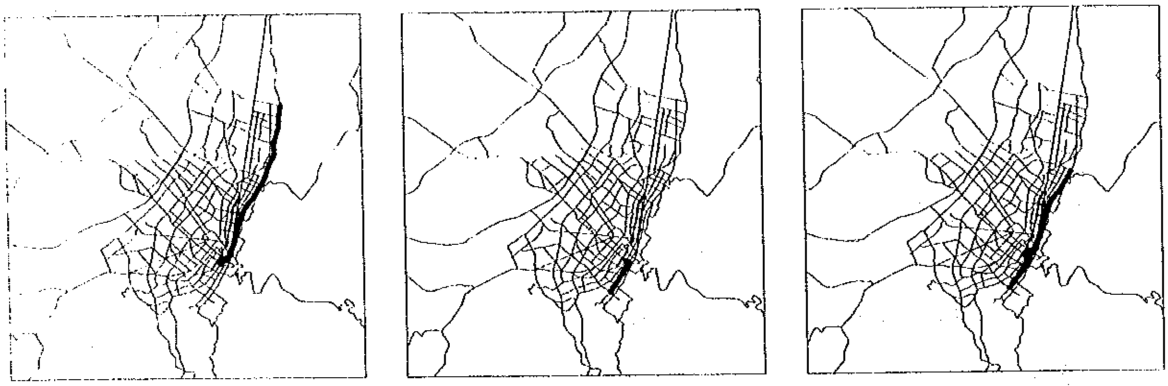



Figure 7.3-6 Alternative-1 of Trunk Bus Routes in 2005

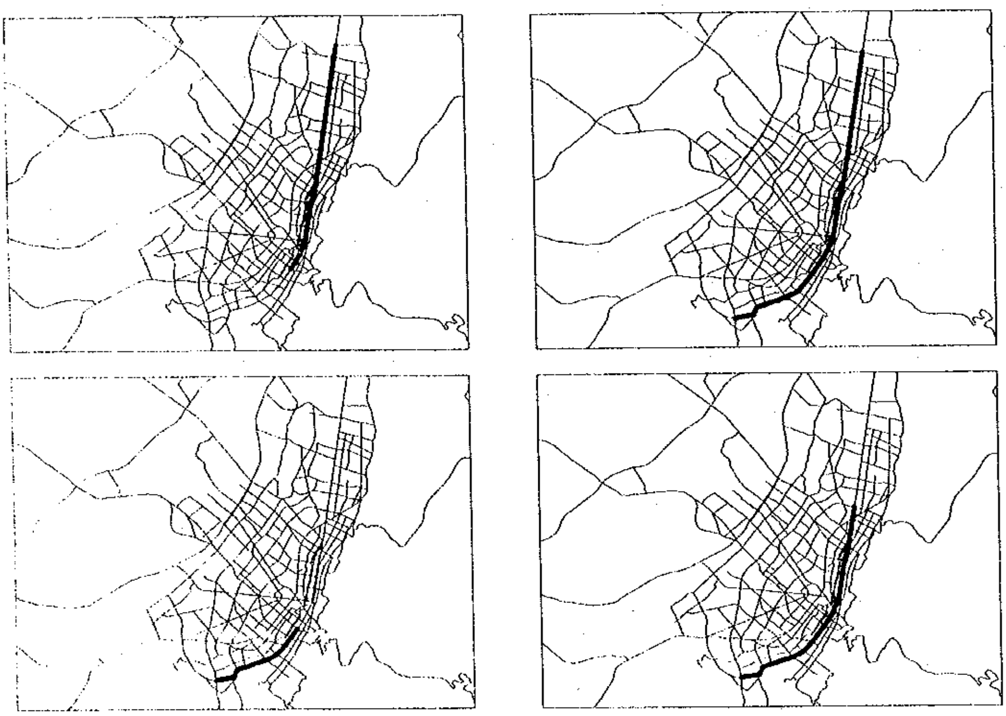
## Components of Each Bus Route of Alternative-1

1) Cra. 7a
2) Caracase-Norte
3) Av. Suba
4) Calle 80
5) Av. Cuidad de Quito-Autopista Sur
6) Av. 68
7) Centenario
8) Av. de las Americas
9) Av. Boyaca-Calle 170

**(1) cra 7a.**



**(2) Caracas - Norte**



**(3) Suba**

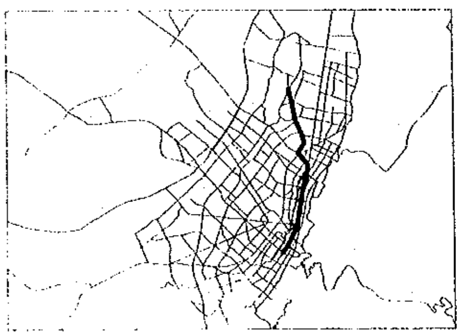
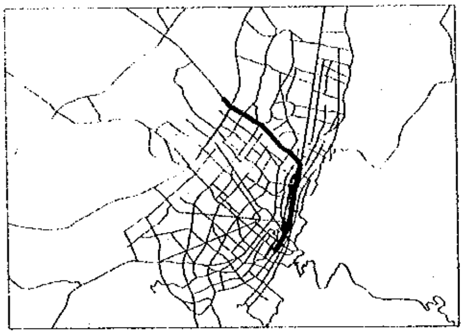
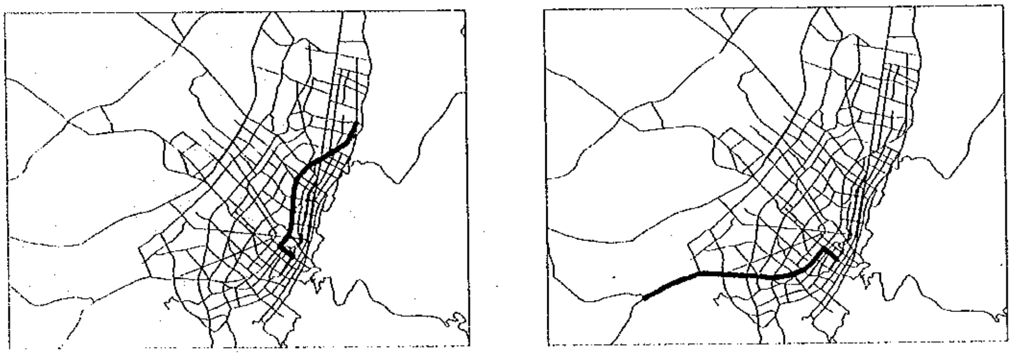


Figure 7.3-7 Bus Route Components of Alternative-1 (1)

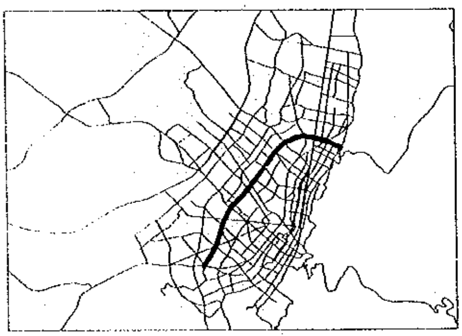
**(4) Calle 80**



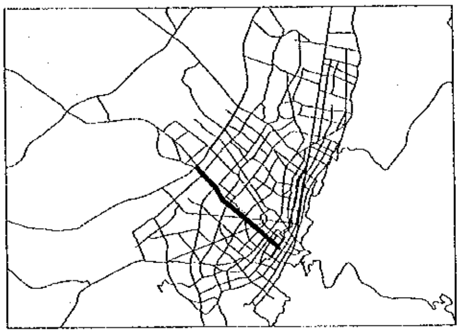
**(5) Quito - Auto Sur**



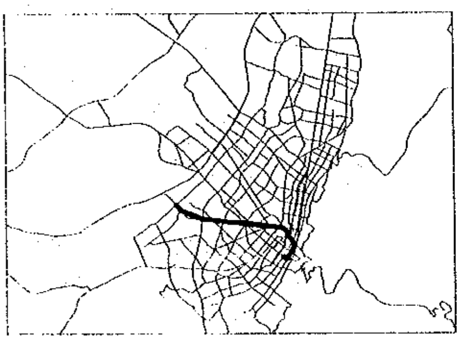
**(6) Av 68**



**(7) Centenario**



**(8) Americas**



**(9) Boyaca - Calle 170**

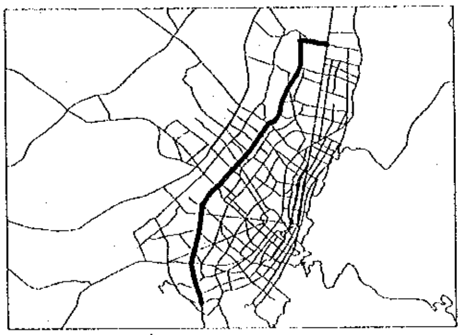


Figure 7.3-8 Bus Route Components of Alternative-1 (2)

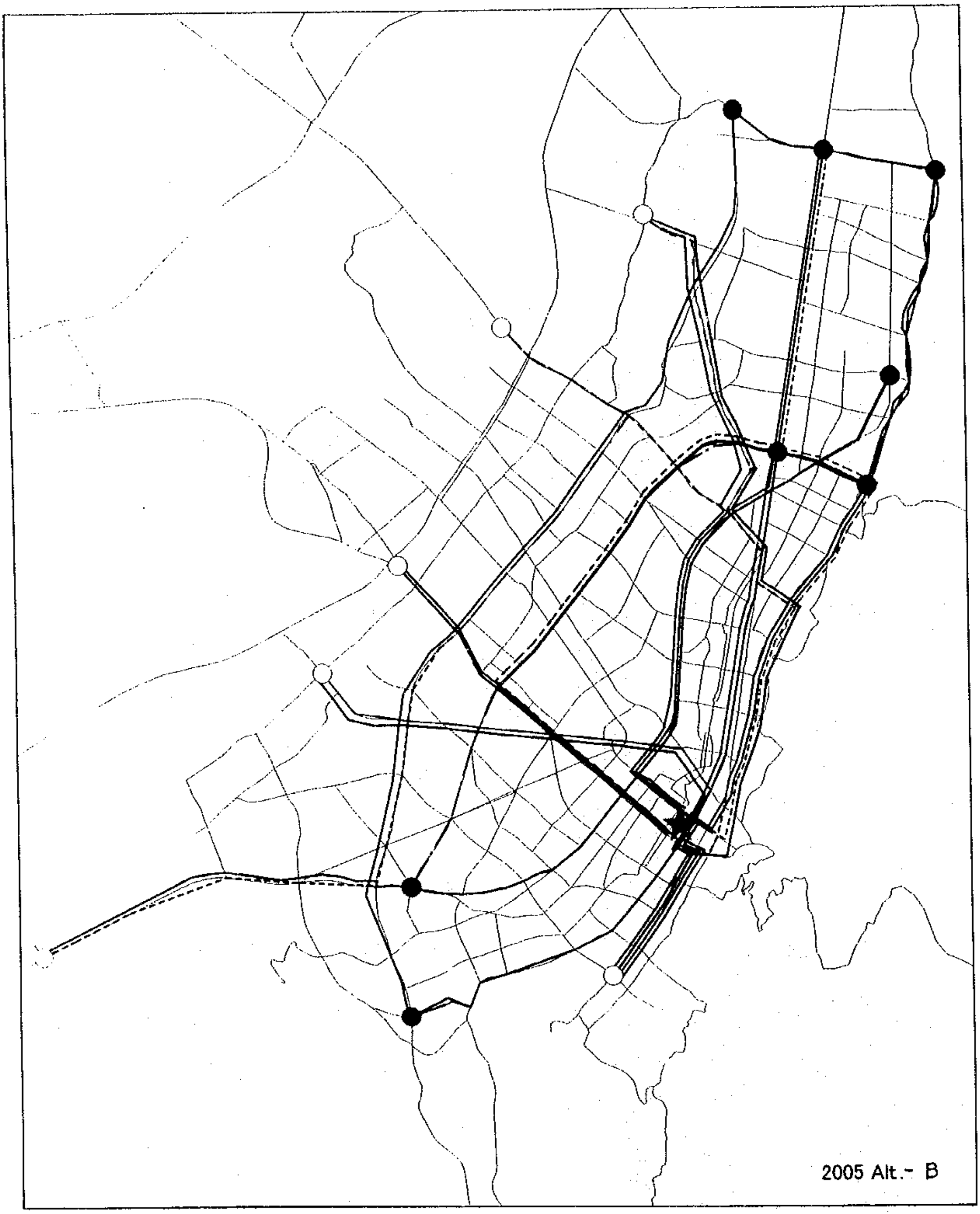



Figure 7.3-9 Alternative-2 of Trunk Bus Routes in 2005

## Components of Each Bus Route of Alternative-2

1) Cra. 7a
2) Caracase-Norte
3) Av. Suba
4) Calle 80
5) Av. Cuidad de Quito-Autopista Sur
6) Av. 68
7) Centenario
8) Av. de las Americas
9) Av. Boyaca-Calle 170

**(1) cra 7a.**

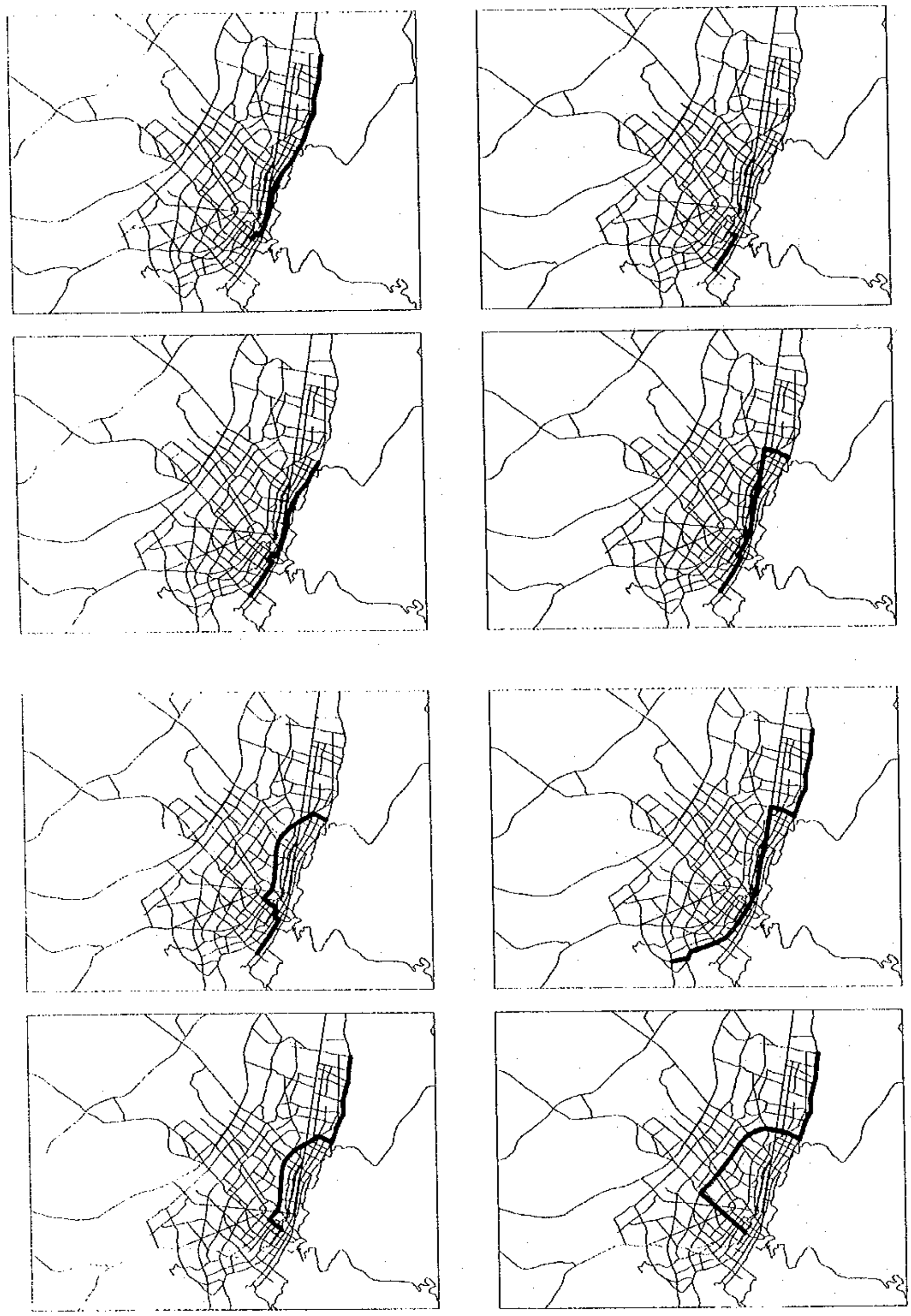


Figure 7.3-10 Bus Route Components of Alternative-2 (1)

## (2) Norte - Caracas

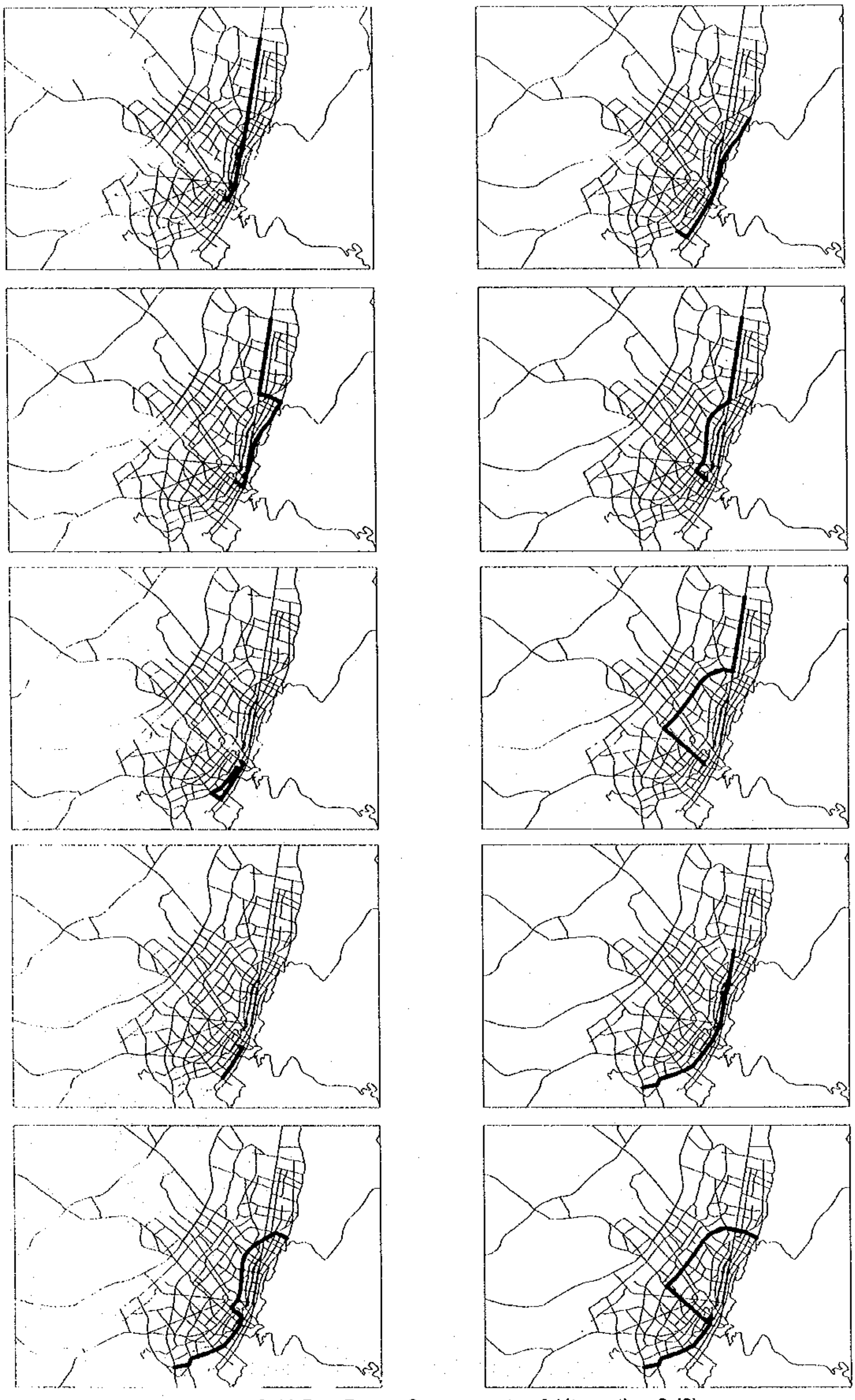


Figure 7.3-11 Bus Route Components of Alternative-2 (2)

### (3) Suba

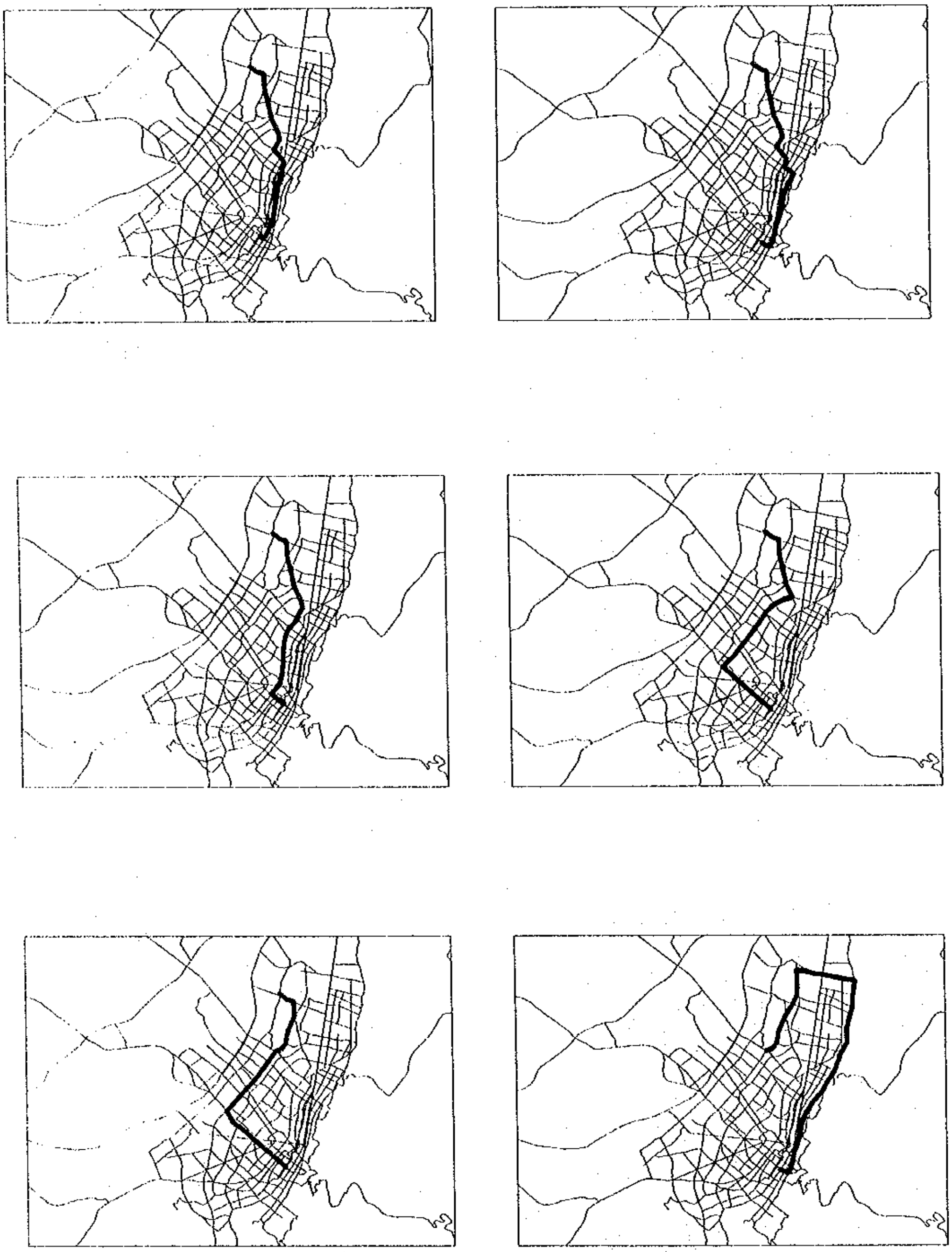


Figure 7.3-12 Bus Route Components of Alternative-2 (3)

**(4) Calle 80**

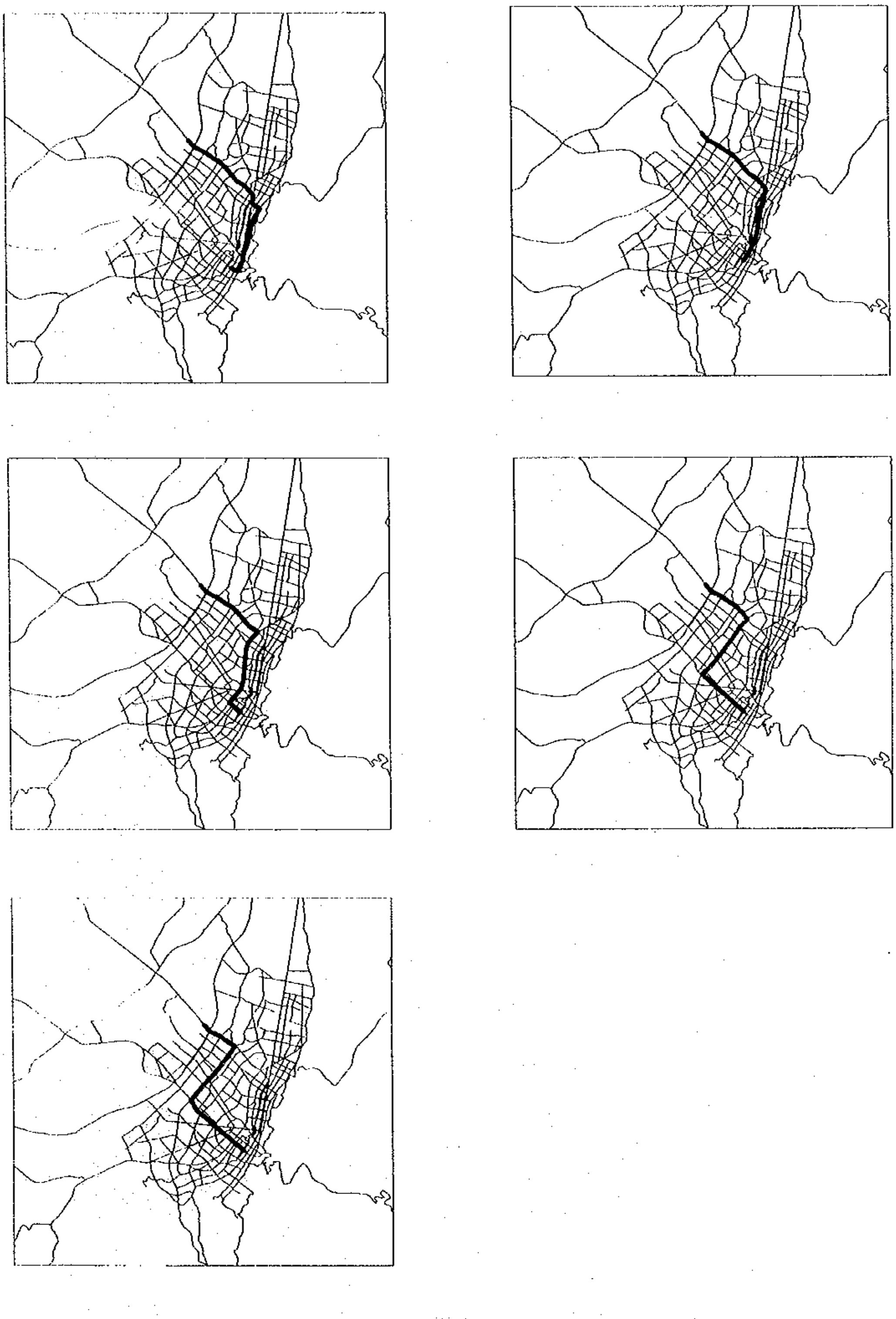


Figure 7.3-13 Bus Route Components of Alternative-2 (4)

## (5) Quito - Auto Sur

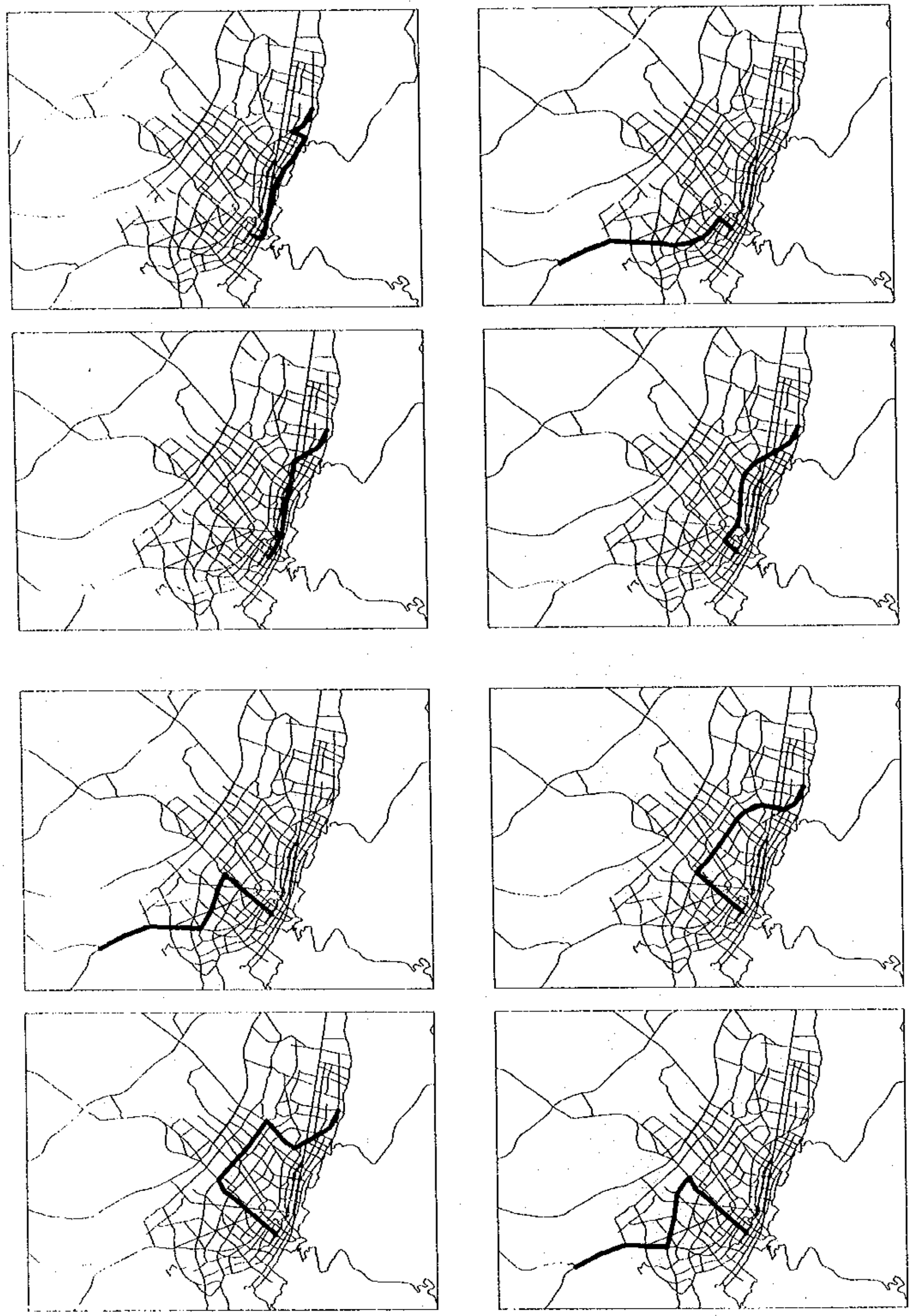


Figure 7.3-14 Bus Route Components of Alternative-2 (5)

### (6) Centenario

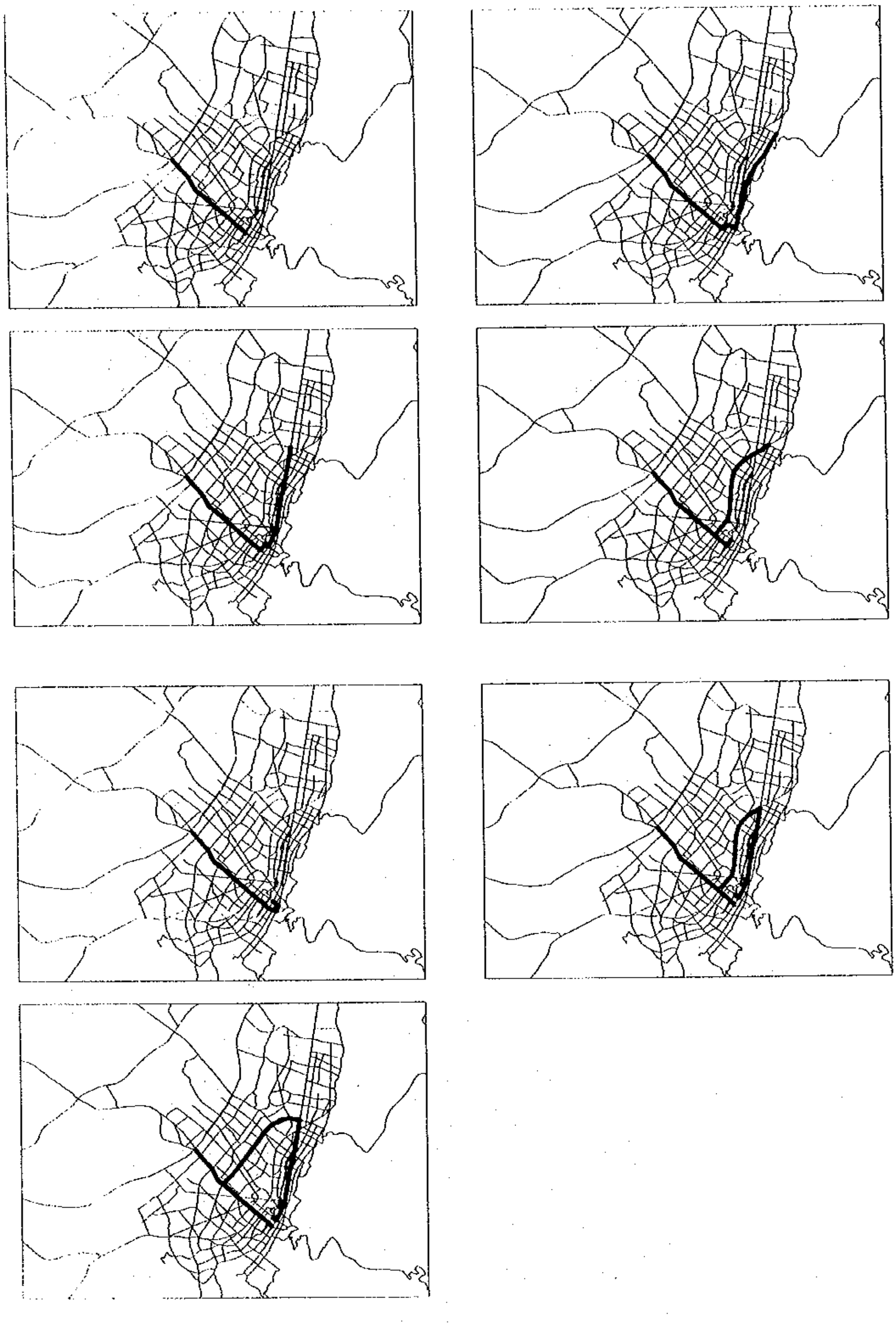
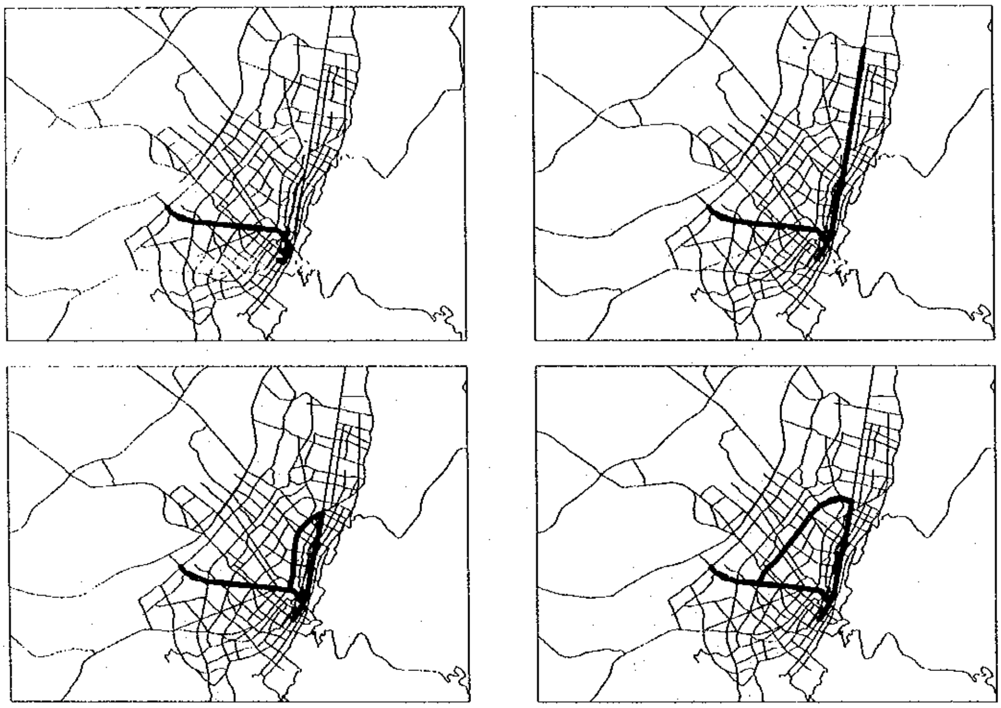
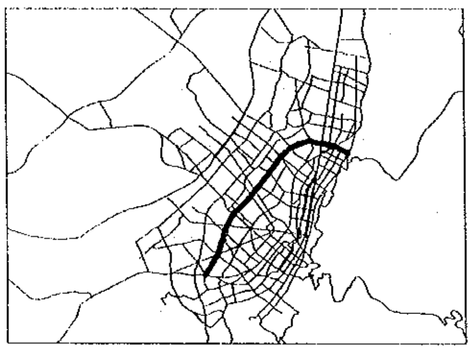


Figure 7.3-15 Bus Route Components of Alternative-2 (6)

**(7) Americas**



**(8) Av 68**



**(9) 170 - Boyaca**

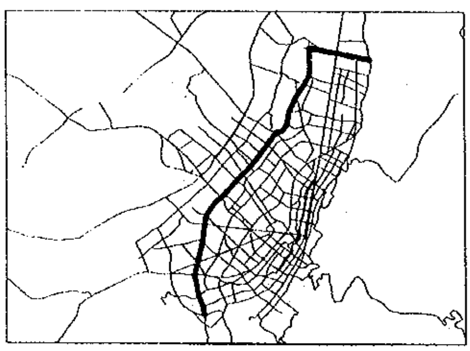


Figure 7.3-16 Bus Route Components of Alternative-2 (7)


Figure 7.3-17 Bus Passenger OD Pairs on Av. Cra. 7a, Cra. 10, and Av. Ciudad de Quito

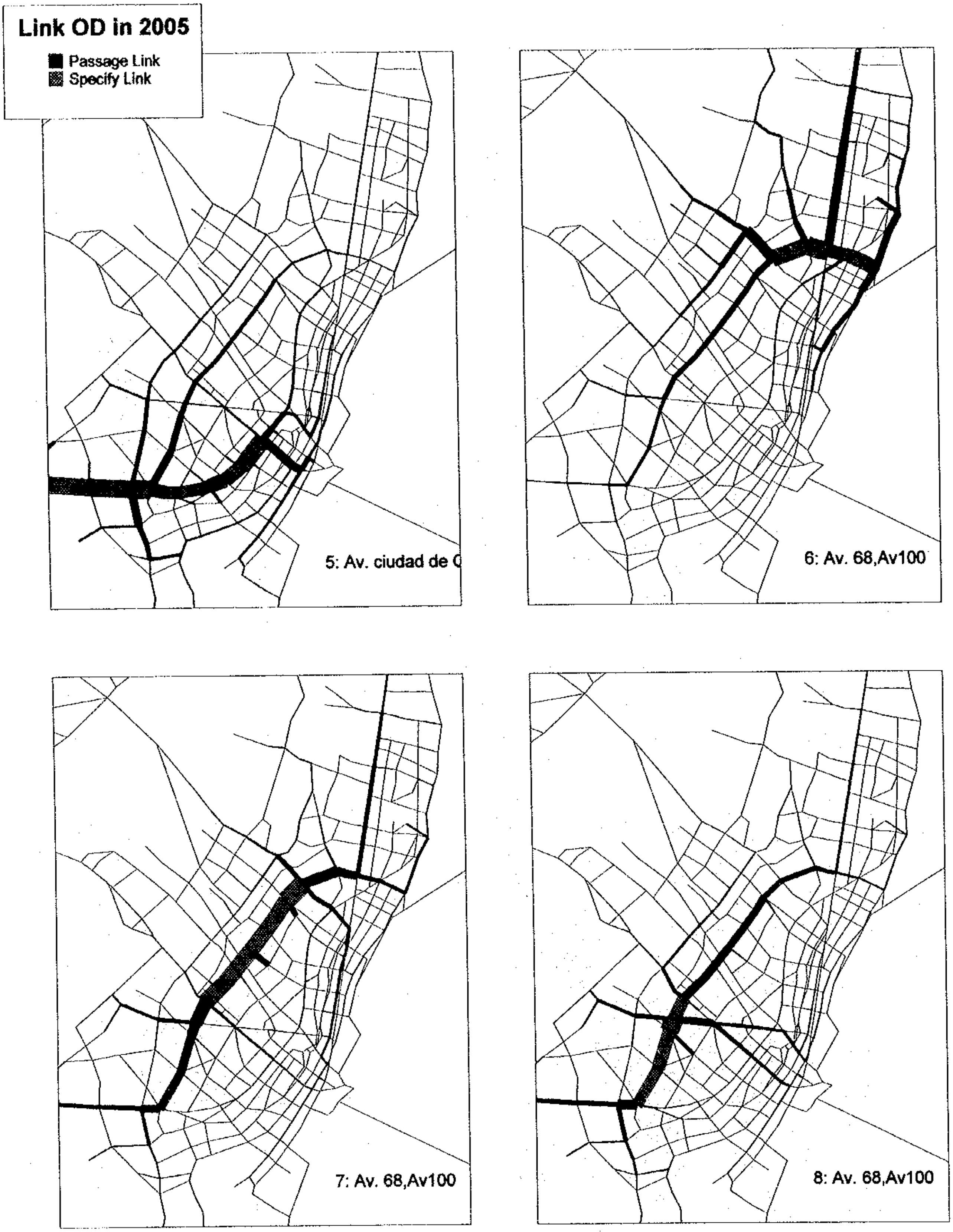



Figure 7.3-18 Bus Passenger OD Pairs on Av. 68 and Av. 100


Figure 7.3-19 Bus Passenger OD Pairs on Calle 170, Av. Suba and Av. Caracas


Figure 7.3-20 Bus Passenger OD Pairs on Av. Boyaca and Calle 80

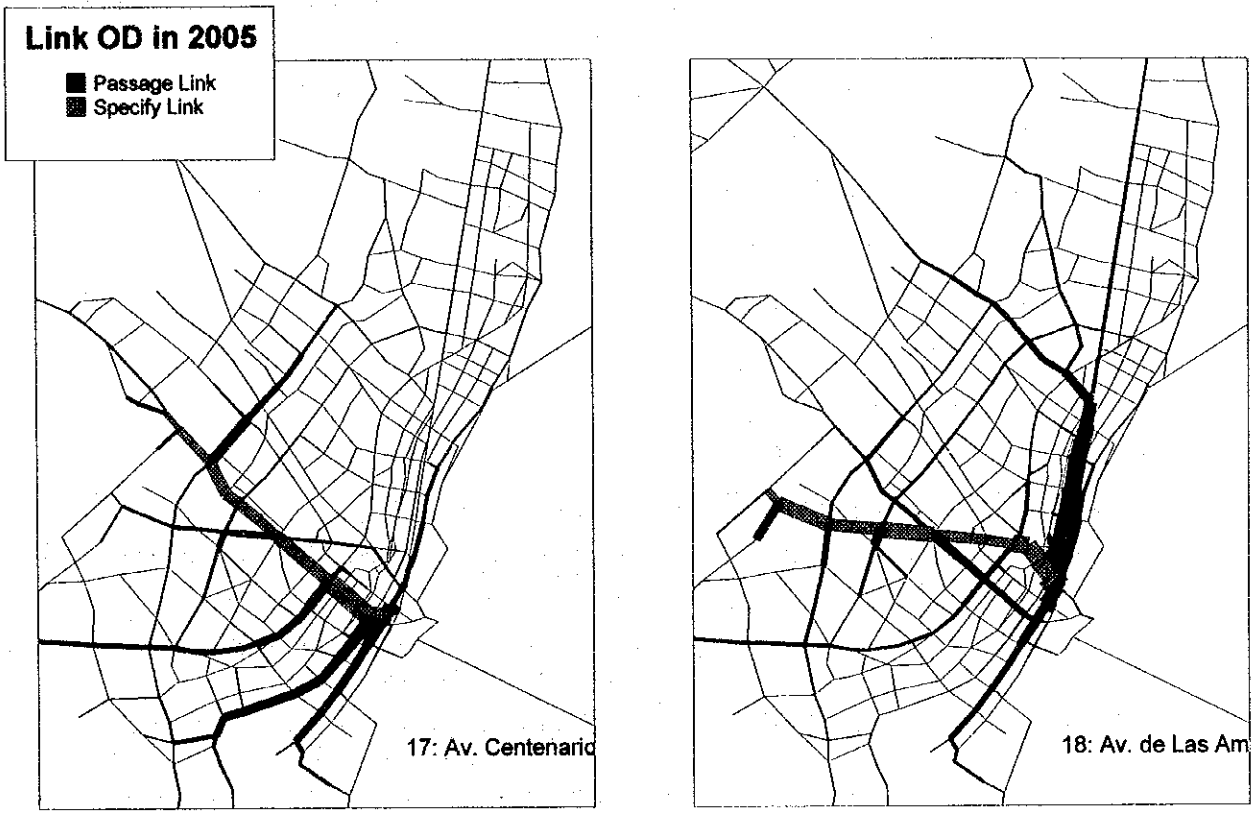



Figure 7.3-21 Bus Passenger OD Pairs on Av. Centenario and Av. de las Americas

### 7.3.4. BUS FLEET SYSTEM

#### (1) General

In trunk and feeder bus system, line-haul capacity can be enhanced by the use of high-capacity buses, whether articulated, double-deck or with the use of bus+trailer. As for passenger transfer capacity at bus stops, however, the door configuration, number of doors, ticketing arrangements, etc. are often more important than bus capacity alone.

Bus characteristics to influence trunk bus system performance are as follows:

1) Vehicle size and capacity
2) Existence and control of doors
3) Number, location, width and use of doorways
4) Number and height of steps
5) Floor height
6) Maximum speed
7) Acceleration and deceleration rates

The general merits of large or small sized buses are as follows.

1) Operation costs per unit of offered capacity decrease as bus fleet size increase. This is mostly due to higher labor productivity.
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. Large buses are less convenient and slower on routes with many turns, narrow lanes, and so on. An exception to this may be articulated buses: a 16-m-long articulated bus is more maneuverable than a single-body bus with maximum length (12 m).
4) Riding comfort increases with single-body buses, but is lower with articulated and double-decker buses.

The selection of bus size is usually a complex task because the relative importance of these factors varies with local conditions. Thus, on some routes, maneuverability is as important factor against the maximum size buses: many European cities find 11 m regular and 16.5 m articulated buses preferable to the maximum-length buses (12 to 18 ms), owing to their narrower turning paths. Often, however, operating costs and service reliability are the dominant factors. Therefore, with increasing demand, capacity should be further increased by introducing larger buses, rather than higher service frequency, which causes higher operating costs and decreases reliability. Figure 7.3-22 shows relationship between service elements and cost of bus service.

In summary, for schedules determined by passenger volumes, larger vehicles offer both lower operating costs and higher service reliability. In Bogota, bus transport is main mode for public transport and public transport demand is heavy, especially in the peak hours. When the trunk and feeder bus system is introduced in Bogota, larger buses on the trunk busway will offer both lower operation cost and higher service reliability.

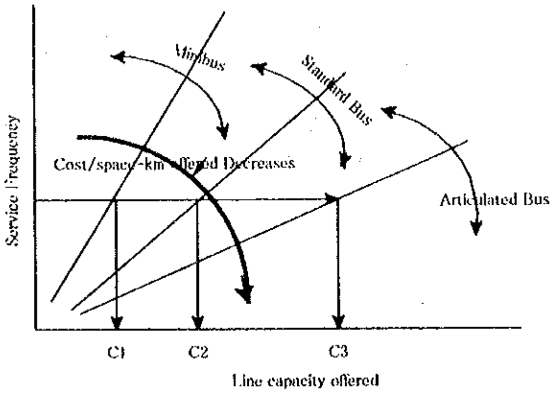



Figure 7.3-22 Relationships between Service Elements and Cost of Bus Service

### (2) Bus Size

At the present bus operation system, larger bus fleet size is approximately 10.5 – 11.5 meters and its passenger capacity is about 45 seats. As mentioned in Section 5.4.3, bus capacity used for trunk and feeder bus operations will be proposed as follows:

1) Trunk bus: 80 – 100 passengers /unit

2) Express bus: 150 – 200 passengers /unit

3) Feeder bus: 15 – 20 passengers /unit

Those passenger capacities of trunk and express buses are almost 2 – 4 times, comparing to the existing bus capacities. With regard to larger size buses, maneuverability is a drawback owing to narrow turning paths from the view point of traffic management.

Figure 7.3-23 shows proposed sizes of trunk and express buses in the Study. The trunk bus uses a standard bus. This is the most common type of transit bus, usually considered as standard, which is a single-body vehicle with two axles, six wheels, and a capacity of 80-100 spaces.

Express bus employs an articulated bus. The articulated bus is a long bus with two bodies connected by a joint which provides a single, continuous interior but allows the vehicle to "bend" while turning. Its overall length is 16 to 18 m. Their total capacity is 120 to 160 spaces. In Curitiba, express articulated buses have a capacity of 160 passengers. A biarticulated bus serves a capacity of 270 passengers.

The most common design of articulated buses is with two axles under the front and one axle under the rear body section. The joint is suspended on the rear overhang of the front section. The articulation joint usually allows bending of the two body sections of up to ±40 to 45° horizontally and ±10 ° vertically.

Several factors make the articulated bus attractive for use. Higher labor productivity in articulated buses reduces operation cost per space-km. Also, there is a need to provide higher passenger capacity: less crowding during peak hours, and seats for more passengers during off-peak hours. Finally larger vehicles utilize street space better and increase line capacity.

As for the turning path at intersections, in spite of their 50% greater length, articulated buses usually have the same turning radius and a narrower turning path than standard buses.

The paths of the rear wheels fall within the paths of the front and middle axle wheels, allowing the bus to make any turn a standard bus can make.

To obtain an operating speed similar to that of standard buses, articulated buses typically must have three to four doors. Another requirement is that they have a self-service fare collection system. This fare collection method allows simultaneous boarding/alighting on all doors so that heavy passenger volumes can be handled without major delays.

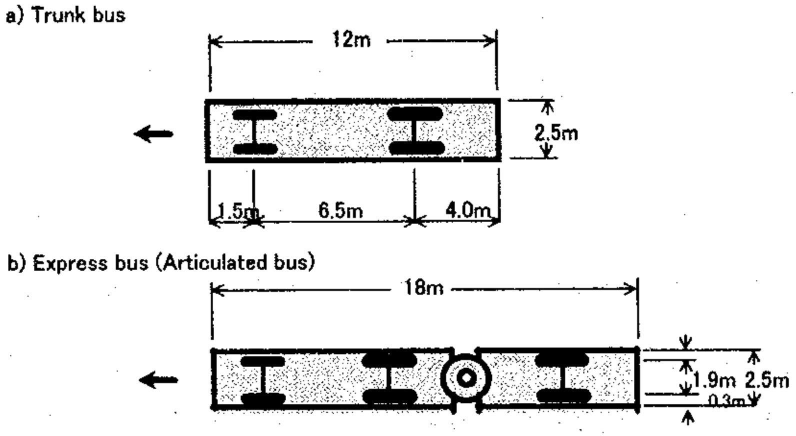



Figure 7.3-23 Sizes of Trunk Buses

### (3) Doors

Boarding and alighting from buses affects passenger convenience, accessibility by passengers and dwell time at bus stops, which in turn directly affects operating speed and the cost service. The vehicle capacity-to-door channel ratio is the basic design factor for determining the number and width of doors. This ratio should be smaller for routes with short trips and heavy passenger interchange. Some standard buses for busy routes in European cities have three double-channel doors, and a capacity-to-door channel ratio as small as 12:1. Most common European designs have two double-channel doors and a ratio of about 20:1.

Door widths of 670 to 830 mm, typical for U.S. buses, have boarding /alighting rates of 1 to 4 seconds per person, depending on whether fare is collected, what type of fare, baggage carrying, and so on. This figure of boarding /alighting time per person in Bogota is approximately 3 seconds. Double-channel doors with widths between 1200 and 1400 mm are used in the majority of overseas cities. They allow much faster boarding.

Therefore, the proposed buses for trunk bus should have three double-channel doors with widths between 1200 and 1400 mm.

For articulated buses, it is extremely important to maintain the same capacity-to-door channel ratio as for standard buses. One double-channel door for boarding and two double-channel doors for alighting represent the minimum required for most urban transit routes.

### 7.3.5. TARIFF SYSTEM

In the conceptual plan (Section 5.4.5), the following two alternative cases are proposed:

1) Alternative-A: a flat rate system with an additional fare at every transfer.

2) Alternative-B: a flat rate system without payment of an additional fare when transferring.

Alternative-B allows transfer without any additional fare when passengers transfer from/to feeder buses or trunk buses at terminal. However, it is difficult to verify passengers who transfer or not for the validation of tickets. In Curitiba, a "tube" station like a railway station as a segregated structure to verify passengers was constructed. Passengers transferring at the tube stations are not allowed to exit to outside of station. When the fare system of Alternative-B is planned, it is indispensable to construct facilities to verify passengers who transfer or not.

### (1) Stage 1 (in 2000)

The present fare system is employed in the Stage 1. The fare system is examined on the following conditions:

1) A flat rate system with an additional fare at every transfer is employed.

2) A fare rate of trunk bus is the same rate as that of present buses.

3) A fare rate of 430 pesos is adopted in the transit assignment

The present fare rate employs a weight average rate of Bus, Buseta and Microbus in terms of service frequency-km. Table 7.3-1 shows the tariff table (for examination) at Stage 1. The following bus riding examples are shown:

- Trunk bus to trunk bus: 430+430 $pesos
- Trunk bus to ordinary bus: 430+430 $pesos
- Ordinary bus ->trunk bus -> ordinary bus: 430+430 $pesos

Table 7.3-1 Tariff Table in 2000

(Unit: pesos/ride)

| | One ride | Transfer Charge | |
|---|---|---|---|
| | | Trunk Bus | Ordinary Bus |
| Trunk Bus | 430 | 430 | 430 |
| Ordinary Bus | 430 | 430 | 430 |

### (2) Stage 2 (in 2005)

#### *1. Alternative-A*

Alternative-A is employed as a basic case in Stage 2. The fare system is examined on the following conditions:

1) A flat rate system with an additional fare at every transfer is employed.

2) A fare rate of trunk bus is 400 pesos at initial condition.

3) A fare rate of 150 pesos is adopted for feeder bus rate.

Table 7.3-2 shows the tariff table to examine the alternatives. These tariff rates are initial conditions for analysis of tariff system on the assumption that total sales under current system balance those under new system. The following bus riding examples are shown:

- Trunk bus to trunk bus: 400+400 $pesos
- Feeder to trunk buses: 400+150 $pesos
- Feeder -> trunk ->feeder buses: 150+400+150 $pesos
- Feeder ->feeder buses: 150+150 $pesos

Table 7.3-2 Tariff Table of Alternative-A in 2005

(Unit: pesos/ride)

| | One ride | Transfer Charge | |
|---|---|---|---|
| | | Trunk Bus | Ordinary Bus |
| Trunk Bus | 400 | 400 | 150 |
| Ordinary Bus | 150 | 400 | 150 |

### *1) Alternative-B*

Alternative-B is employed in the Stage 2. The fare system is examined on the following conditions:

1) A flat rate system without payment of an additional fare when transferring is employed.
2) A fare rate of trunk bus is 400 pesos at initial condition.
3) A fare rate of 150 pesos is adopted for feeder bus rate.
4) Transfer rate from trunk to trunk buses is not charged.
5) Transfer rate from feeder to feeder buses is not charged.
6) A fare rate of 550 pesos is adopted for riding on trunk and feeder buses.

Table 7.3-3 shows the tariff table to examine the alternatives. These tariff rates are initial conditions for the analysis. The following bus riding examples are shown:

- Trunk bus to trunk bus: 400 $pesos
- Feeder to trunk buses: 550 $pesos
- Feeder --> trunk -->feeder buses: 550 $pesos
- Feeder -->feeder buses: 150$pesos

Table 7.3-3 Tariff Table of Alternative-B in 2005

(Unit: pesos/ride)

| | One ride | Transfer Charge | |
|---|---|---|---|
| | | Trunk Bus | Ordinary Bus |
| Trunk Bus | 400 | - | 550 |
| Ordinary Bus | 150 | 550 | - |