CHAPTER 9
Future Transport Demand Forecast

9. FUTURE TRANSPORT DEMAND FORECAST

9.1. GENERAL

In the study, public transport demand is estimated based on the travel conditions in the peak hour, but a daily basis is used for economic analysis. This is because the public transport planning of a bus operation system, such as service frequency, bus lines, and number of buses, is critical in the peak hour. Therefore, the future morning peak hour OD trip data is estimated based on the future travel demand forecast in PDTU2001.

In this chapter, the outline of the socio-economic frame is first, estimated in PDTU2001. The second subject of this chapter is the forecasting method for daily travel demand. The daily travel demand is estimated based on the estimated developed through analysis of the Person Trip survey data in PDTU2001, referring to the travel demand model by PDTU2001. Peak-period future travel demand was forecast based on the daily travel demand forecast. The third subject is the estimate of future traffic volume on the project roads. From the traffic flows on those project roads, the necessity of the project roads is discussed. The last subject is the diversion of the car mode to the trunk bus mode. This shows the possibility of diversion of the car mode based on the survey data. Although the project target year is the year 2012, the demand forecast was also conducted in 2007 as a middle year and in 2020 as a long-term period. In PDTU2001, the travel demand forecast was conducted in 2010 and 2020.

9.2. SOCIO-ECONOMIC FRAMEWORK

(1) Whole Study Area

The socio-economic framework, which is composed of the population, employment, school enrollment, and income, was estimated in 2010 and 2020 in PDTU2001. In the study, the socio-economic frameworks in 2007 and 2012 were estimated as the target years in this Feasibility Study by interpolating the socio-economic frame in 2010 and 2020 in PDTU2001.

Table 9.2-1 shows the present and future socio-economic indices in terms of population, employment, students and income. The future population of the study area will reach 2.4 million in 2012 and will increase by 1.29 times during the 10-year period after 2002. The annual population growth rate during the decade is approximately 2.6% per annum. The future economic growth of the study area in 2012 is determined to be 1.33 times during the decade, equivalent to 2.9% per annum in income base as the target for the improvement of the total urban environment of the Belém Metropolitan Area.

Table 9.2-1 Future Population, Employment and Income in 2002, 2007, 2012, and 2020

Items	2002	2007	2012	2020	2007 /2002	2012 /2002	2020 /2002
Population	1,888,959	2,155,383	2,446,073	2,969,470	1.14	1.29	1.57
Employment	537,467	612,108	693,656	840,834	1.14	1.29	1.56
Primary	6,697	6,443	6,305	6,406	0.96	0.94	0.96
Secondary	38,316	43,316	48,923	59,392	1.13	1.28	1.55
Tertiary	492,454	562,349	638,428	775,036	1.14	1.30	1.57
Students	581,608	663,784	753,384	914,595	1.14	1.30	1.57
Income (R$1.00)	865	973	1,150	1,593	1.13	1.33	1.84

(2) Growth in Macro Zone

1) Population

Figure 9.2-1 shows the comparison of population among 2002, 2007, 2012 and 2020 for the macro-traffic zone with a bar graph. The regions with higher growth rates between 2002 and 2012 are Guanabara, Icoaraci, Cidade Nova, Julia Seffer and Ananindeua, which are located in suburban areas. The figures are around 1.56 times during the decade. On the other hand, the growth rate in the Central Area in Belém, which is the business and commercial district, is as low as 1.03 to 1.04. This indicates that the area developing as a residential area extends to the suburbs in the direction of Ananindeua.

This tendency in population estimated during the 10-year period after 2002 is similar to that in the past 10 years after 1990.

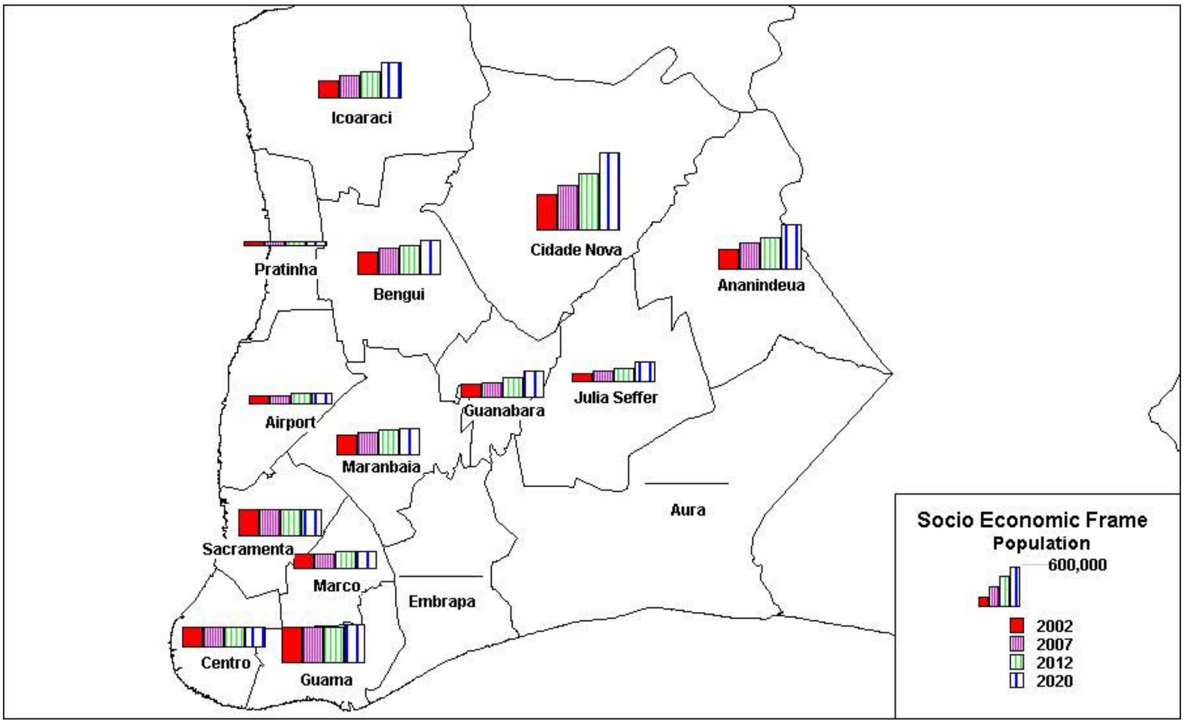


Figure 9.2-1 Comparison of Population among 2002, 2007, 2012, and 2020

2) Employment

Figure 9.2-2 shows the comparison of tertiary employment among 2002, 2007, 2012 and 2020 for the macro-traffic zone. As can be seen, the areas with high tertiary employment are the Central Area (within Primeira Légua Patrimonial) and newly developed areas such as Cidade Nova, Icoaraci, and Marambaia. The regions with higher growth rates between 2002 and 2012 are the Central Area, Guanabara, Julia Seffer and Ananindeua. The figures range from 1.3 to 1.5 times during the decade. The future increase of tertiary employment indicates the growth of commercial and business activities in those areas.

3) Income

Figure 9.2-3 shows the average household income among 2002, 2007, 2012 and 2020 for the macro-traffic zone. The macro-zones with higher income are concentrated in the Central Area. In 2012, the macro-zones with higher than average income in the BMA are Centro, Guama, Sacramento, Marco, Marambaia, and Airport. In the peripheral area, Guanabara and Cidade Nova exceed the average. The regions with somewhat high growth rates between 2002 and 2012 are distributed over the whole study area. Since higher income corresponds closely with motorized households—families that own a car, future car trips will increase in the whole BMA.

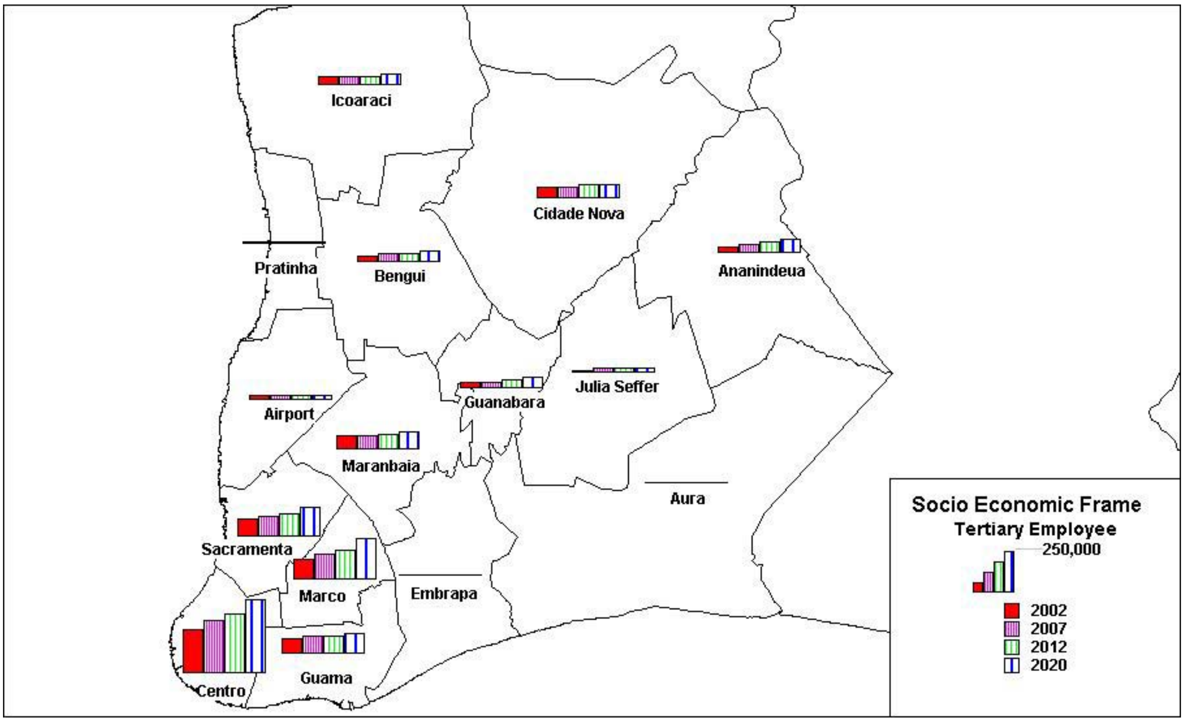


Figure 9.2-2 Comparison of Tertiary Employment among 2002, 2007, 2012, and 2020

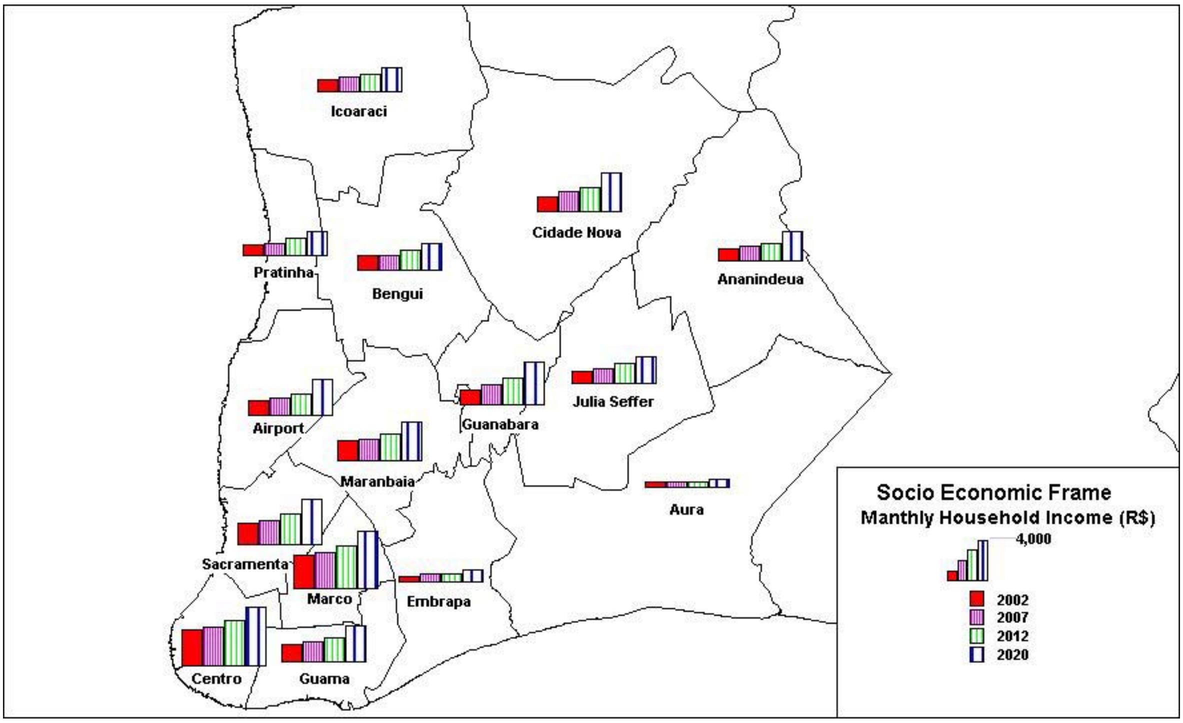


Figure 9.2-3 Comparison of Monthly Household Income among 2002, 2007, 2012, and 2020

9.3. TRAVEL DEMAND FORECAST

9.3.1. GENERAL

In PDTU2001, the future travel demand was estimated in 2010 and 2020, in which car and bus transport demands were forecast in the morning peak-period. The forecasting models developed in PDTU2001 are four-step models: a linear regression model is used for the trip generation and attraction model, the trip end model is used for the modal choice model, the present-pattern method is used for the trip distribution model, and trip assignment is employed as a final step in which all OD trips are assigned on the roads along the corresponding minimum cast paths.

In the study, the future daily and morning peak-period travel demands were forecast for 2007, 2012 and 2020 by private (car/other) and bus transport modes. The forecasting modes basically employed the developed model in PDTU2001. However, all model parameters were estimated again. The daily travel demand was firstly forecast and then, the morning peak-period travel demand was estimated according to the present ratio of peak-period trips to daily trips.

Figure 9.3-1 shows the flowchart of the forecasting model. In the trip generation and attraction model, the model parameters were estimated again based on the 2002 trip OD tables and the present socio-economic data. The trip distribution model was newly developed in the study. Voorhees-type gravity models were developed instead of the present-pattern model adopted in PDTU2001. This because the regions with higher socio-economic growth rates will extend to suburban areas, so a future trip distribution pattern will be considerably different from the present situation.

In the study, the trunk bus system is analyzed under the trunk bus routes on the trunk busway and the trunk bus operation characteristics such as bus service frequency and number of trunk buses on roads must be estimated. Therefore, the bus passengers were assigned on bus routes by the minimum cast paths in the trip assignment method, but for the private mode, private car users were assigned on roads.

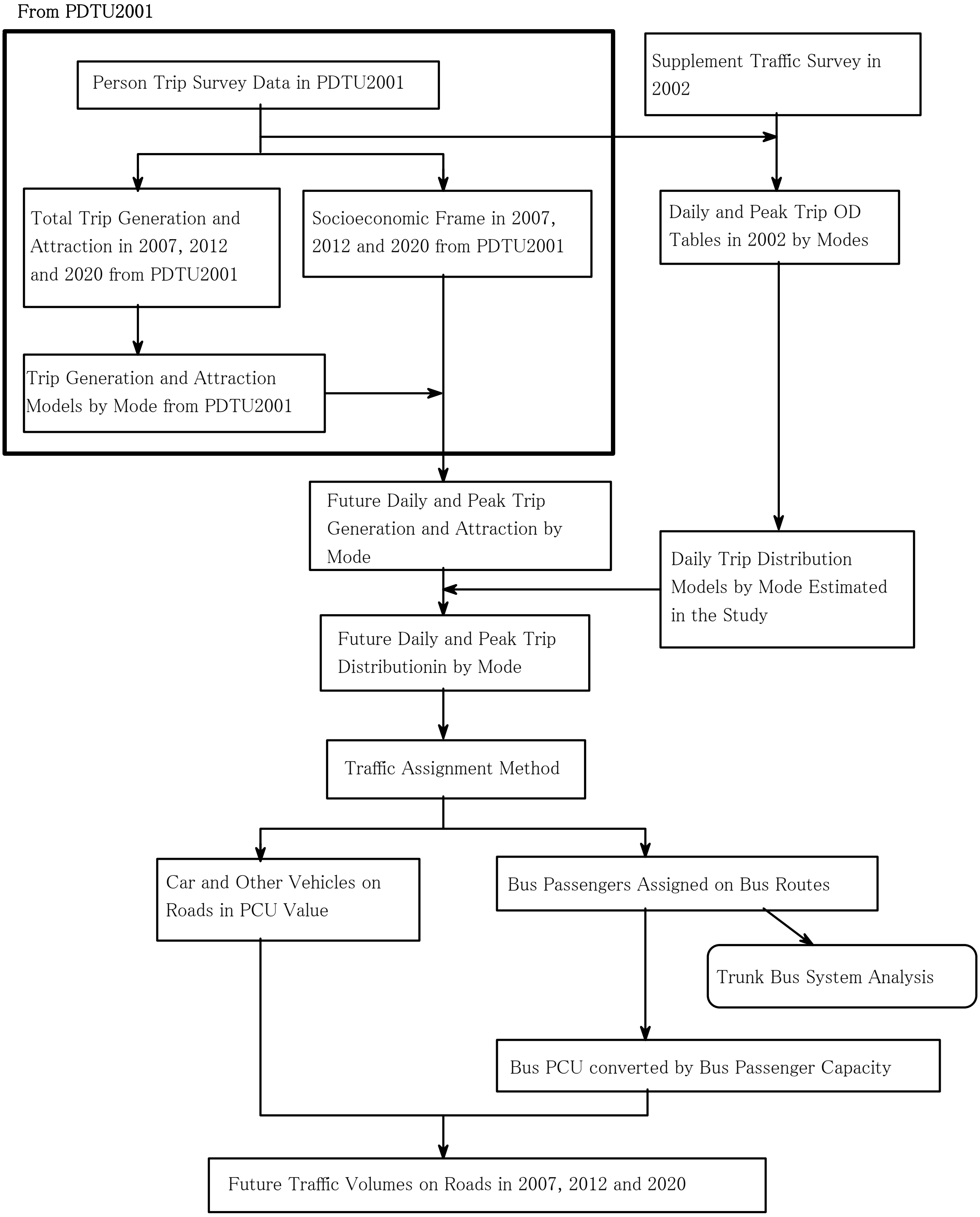


Figure 9.3-1 Flowchart of Forecasting Model

9.3.2. INCREASE OF FUTURE TRAVEL DEMAND BY MODE

In PDTU2001, the future travel demands in the morning peak-period were estimated in 2010 and 2020 in which the increase ratios of car and bus trips are 1.186 and 1.190 in 2007, and 1.406 and 1.416 in 2012, respectively. According to the increase ratio in PDTU2001, both the car and bus trip increase ratios are similar. However, according to the past increase ratios of car and bus between 1990 and 2002, they are quite different: that for cars is 7.5% and that for buses is 0.80% (see Table 9.3-1).

Table 9.3-1 Increase Ratios of Car and Bus Trips in PDTU2001

Type	2007/2002	2012/2002	2020/2002	2002/1990*
Car	3.47%	7.06%	7.97%	7.50%
Bus	3.54%	7.21%	8.14%	0.80%

Source: PDTU2001 excluding figures in the column of "2002/1990"

In the study, since the increase ratio of total number of trips estimated in PDTU2001 (a ratio of 1.41 between 2012 and 2002) is a similar figure to that (1.35) in the method which multiplies the population growth ratio (1.29) and increase of number of trips per person (estimated by the increase ratio of income per capita (1.04)) in the future socio-economic frame, the total number of trips (car and bus) according to PDTU2001 was used as a control total value. The annual increase ratios of car and bus trips, however, were reviewed. Also, future trunk/other trips were forecast, though those trips were not estimated in PDTU2001.

The future car trips are estimated on the assumption that future car trips are in proportion to the figures for the future number of cars multiplied by the increase ratio of number of car trips per vehicle. The estimation of the number of cars used the linear regression model with a variable of household income developed in PDTU2001. By this method, the future car trips were estimated and the difference between total trips and car trips is bus trips. Table 9.3-2 and Figure 9.3-2 show the estimated car/other and bus trips in the future. Table 9.3-3 shows the future annual increase ratio of car/other and bus trips in the peak-period.

Table 9.3-2 Estimated Car and Bus Trips in 2007, 2012 and 2020

Type	2002	2007	2012	2020	2007 /2002	2012 /2002	2020 /2002
Peak Period							
Car/Other	113,292	156,363	220,631	399,579	1.380	1.947	3.527
Bus	298,576	335,230	366,191	380,637	1.123	1.226	1.275
Total	411,868	491,593	586,822	780,216	1.194	1.425	1.894
Daily Trips							
Car/Other	925,841	1,272,619	1,787,881	3,183,302	1.375	1.931	3.438
Bus	1,701,826	1,911,700	2,088,226	2,170,307	1.123	1.227	1.275
Total	2,627,667	3,184,319	3,876,107	5,353,609	1.212	1.475	2.037

Table 9.3-3 Annual Increase Ratio of Car and Bus Trips in Peak-Period

Year	2002/1990	2007/2002	2012/2007	2020/2012
Car/Other	7.5%	6.7%	7.1%	7.7%
Bus	0.8%	2.3%	1.8%	0.5%
Total	2.2%	3.6%	3.6%	3.6%

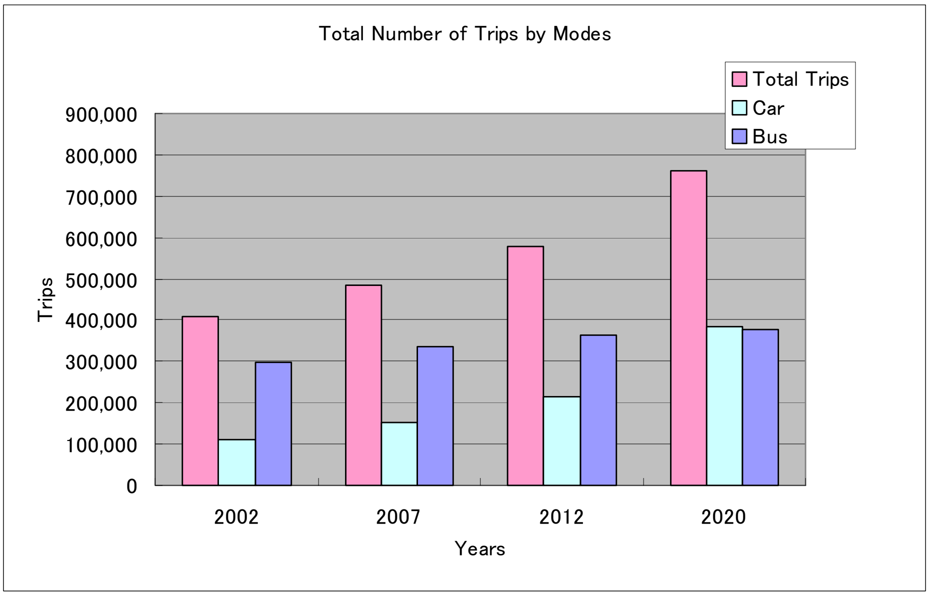


Figure 9.3-2 Total Number of Trips by Mode in 2007, 2012 and 2020

9.3.3. TRIP GENERATION AND ATTRACTION

(1) Trip Generation and Attraction Model

Trip generation and attraction models refer to the linear regression model by car and bus developed in PDTU2001, but the estimation of model parameters were forecasted according to the latest trip OD tables in 2002.

In the study, trip generation and attraction models were estimated according to the daily-based trip OD tables in 2002. The future peak hour trips are forecast by multiplying the ratio of present peak hour trips to daily trips by future daily trips estimated in this model.

a) Car Mode on Daily Base

Generation=Employment (home base) * 0.384538 + Car Owning * 90610.52, $R^2 = 0.818$

Attraction= Employment (working place) * 2.098731 + (Students/Population)* 246.9942 -3110.2, $R^2 = 0.912$

b) Bus Mode on Daily Base

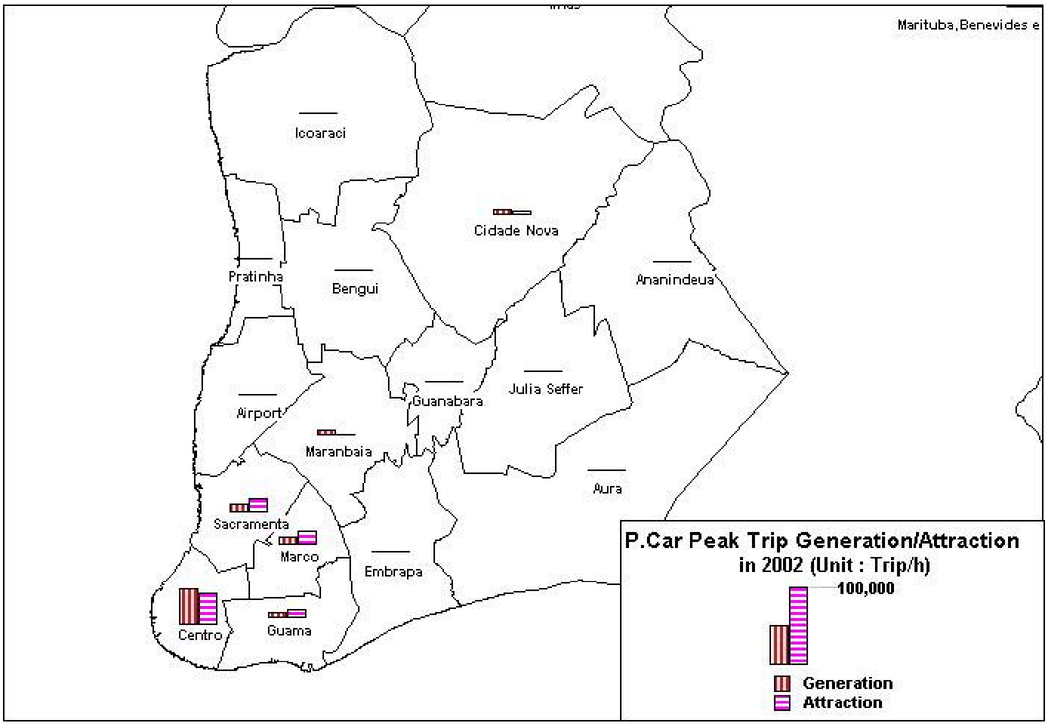
Generation = Employment (home base) * 2.73943 + Car Owning * 177.9001, $R^2 = 0.989$

Attraction= Employment (working place) * 3.014145 + (Students/Population)* 2562.656, $R^2 = 0.924$

(2) Projection

Figure 9.3-3 and Figure 9.3-4 show the trip generation and attraction in the morning peak hour in 2002 and 2012 by bus and car modes, respectively. These figures show a comparison between the figures in 2002 and 2012. As can be seen, the increase rates of car trip generation between 2002 and 2012 in the suburban areas are considerably higher (2.0-3.0), while in the Central Area they are slightly higher (1.5 – 1.9). The bus trips rise 1.5 to 2.0 times in the suburban area and 1.07-1.10 times in the central.

As for trip attraction, the car increase rate of the Central Area is similar (1.5 – 1.9) to that in the generation. In the suburban area, the figures are also higher (2.0 – 3.5). This is because the growth rates of population and income are higher in the suburban area (see Figure 9.2-1 and Figure 9.2-2).



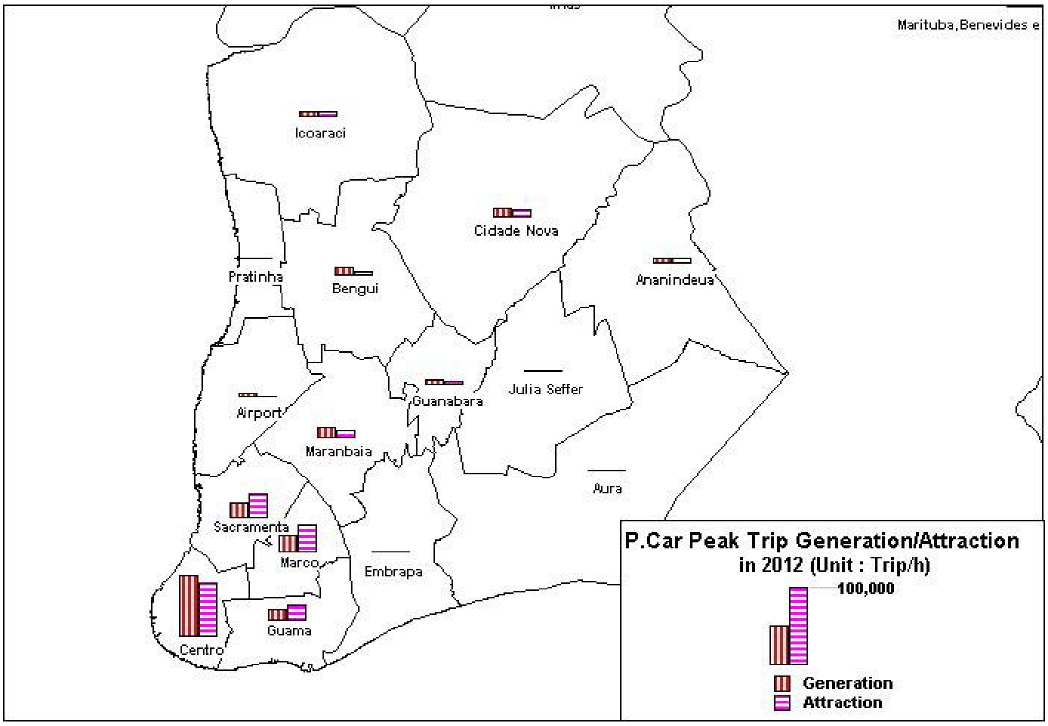
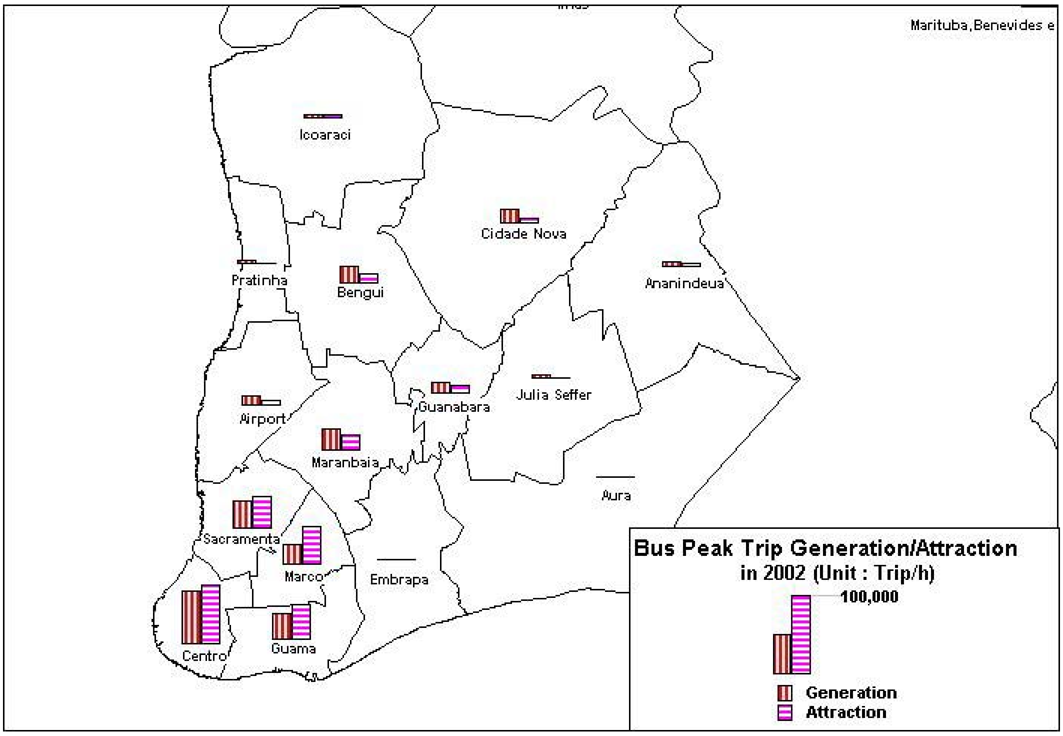


Figure 9.3-3 Peak Hour Trip Generation and Attraction by Car Mode in 2002 and 2012



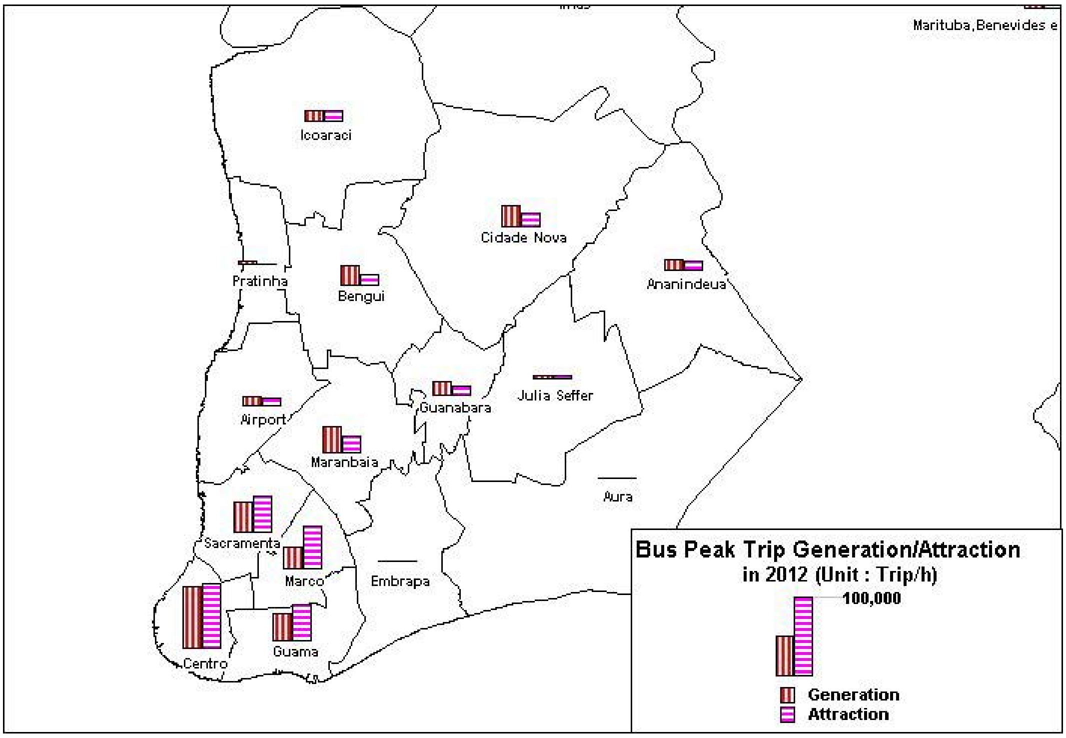


Figure 9.3-4 Peak Hour Trip Generation and Attraction by Bus Mode in 2002 and 2012

9.3.4. TRIP DISTRIBUTION

(1) Trip Distribution Model

For the trip distribution step, "a doubly constrained growth factor method" known as the present-pattern method was adopted in PDTU2001. This was because in the Belém Metropolitan Area, the future networks for road transport and public transport, as well as the land use patterns, will not dramatically change and the employment of the gravity model will not be strong enough.

However, in the study, the gravity model was developed and applied for the estimation of future trip distribution to reflect the influence of traffic and transport occurring from future road improvement and construction.

TheVoorhees-type gravity model employed in PDTU1991 was developed in the daily-base model as shown below, but for estimation of model parameters which were forecast according to the latest trip OD tables in 2002 and for the future road network.

$$Tij = Gi \frac{AjDij^{\alpha}}{\sum AjDij^{\alpha}}$$

Tij: OD trips between zone i and zone j

Gi: Generation trips from zone i

Aj: Attraction trips from zone j

Dij: Road distance between zone i and zone j

α : parameter

Private α : -0.000052, R^2 : 0.75787

Bus α : -0.000265, R^2 : 0.75788

(2) Projection

Figure 9.3-5 and Figure 9.3-6 illustrate the desire lines in the morning peak hour by the car and bus modes for inter-zonal trips in 2002 and 2012. As seen in the car mode, heavy trip flows in 2012 cover the whole Central Area, and the trips with a somewhat high degree rush into the Central Area from the suburban area. Compared to the strong desire lines predominant within the Central Area in 2002, OD trips in 2012 linked between the Central Area and suburban areas considerably increase.

As for the bus mode, heavy trip flows in 2012 cover the whole study area, and invade into the Central Area to a somewhat high degree. Compared to the strong desire lines predominant within the Central Area in 2002, OD trips in 2012 linked between the Central Area and suburban areas, and within suburban areas slightly increase.

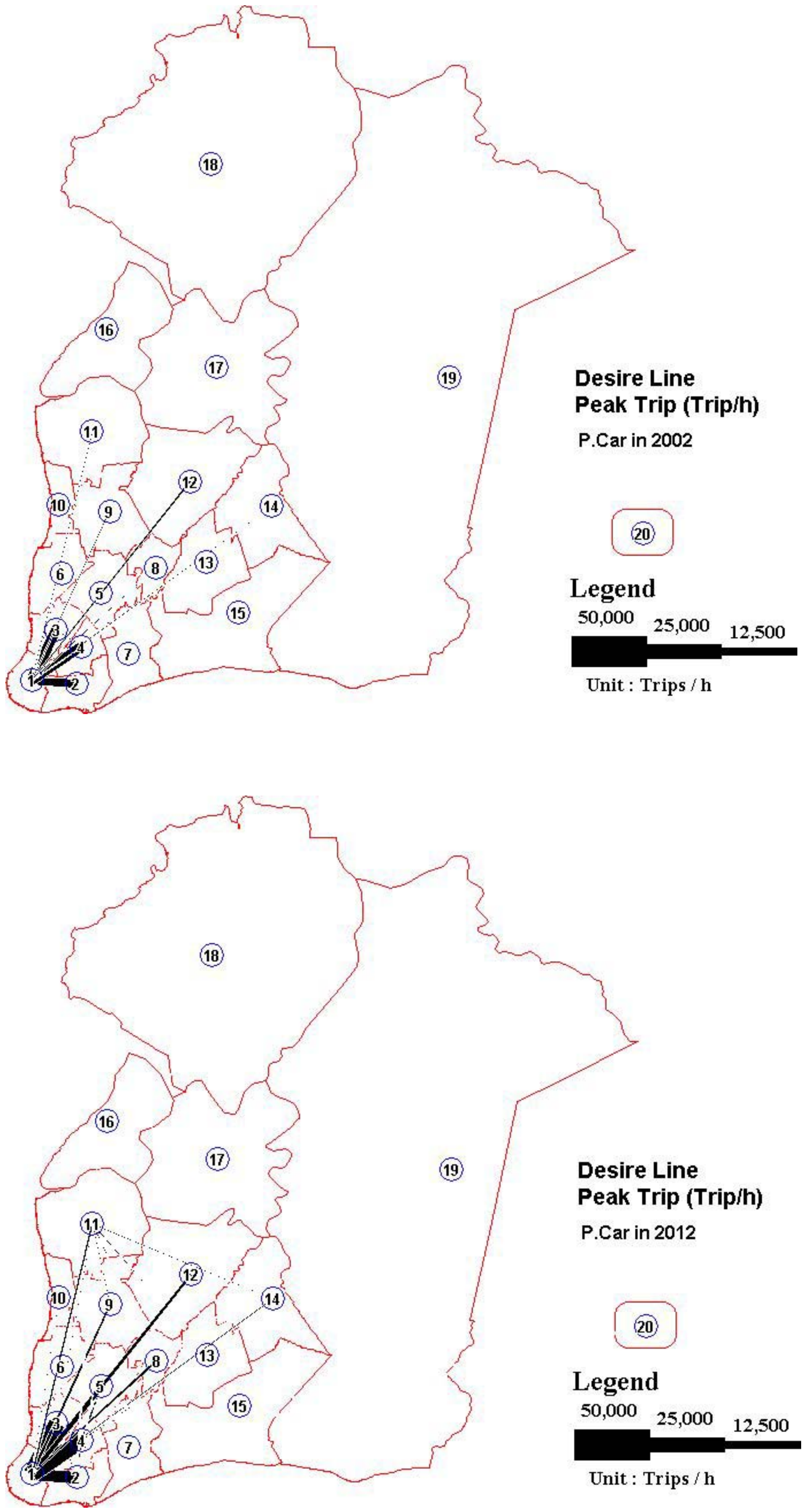


Figure 9.3-5 Peak Hour Trip Desire Lines by Private Mode in 2002 and 2012

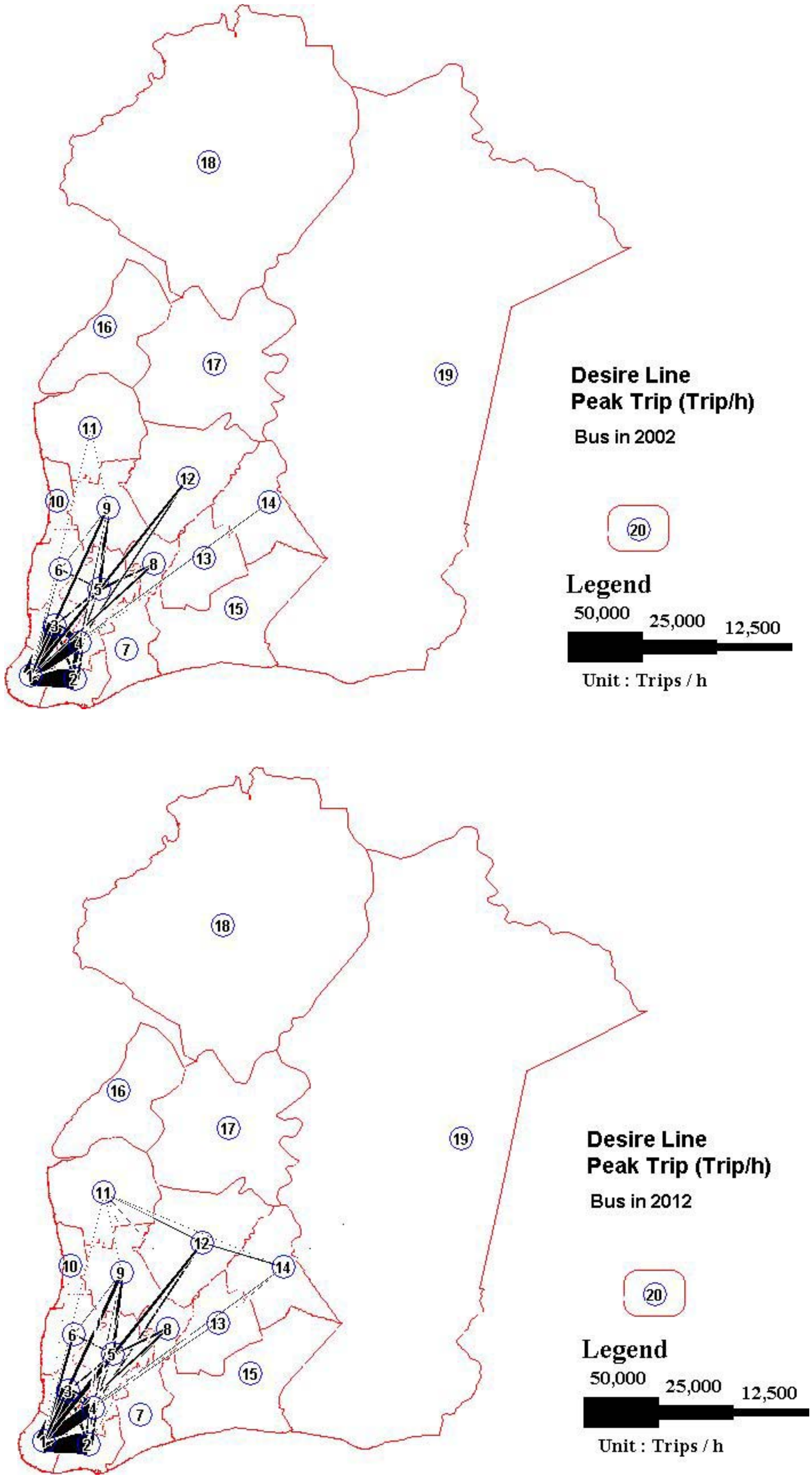


Figure 9.3-6 Peak Hour Trip Desire Lines by Public Mode in 2002 and 2012

9.3.5. TRIP ASSIGNMENT

(1) Procedure

The last step in the four-step method is the assignment of the predicted modal flows between each origin-destination pair to actual routes through the given mode's network. In this study, the traffic assignment model has two systems. One is for private vehicles such as cars and trucks on roads. The private vehicle passes on a minimum distance/time route chosen in this model. The other is for public transport (buses) on fixed routes. The buses are assigned on fixed routes prepared in the model. Both assigned traffic volumes were combined on the same road network after conducting traffic assignment separately (see Figure 9.3-1)

(2) Calibration

In order to evaluate 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 the peak hour bus passenger OD trip table. All the present 165 bus routes were input to the transit assignment model to accurately reproduce actual bus flow conditions.

Figure 9.3-7 and Figure 9.3-8 show comparisons between actual bus service frequency and estimated frequency by roads and bus routes, respectively. This service frequency means bus flows on roads. These figures—actual frequency and estimated frequency—are in the ratio of 1:1 on the scatter gram in the graph. Figure 9.3-9 shows assigned bus flows on roads in the study area. The results of validation for operation are sufficiently satisfactory.

The transit model also estimates the number of transfers at bus stops. Figure 9.3-10 shows actual bus transfer times by the public transport survey and estimated times by the bus transit assignment. The estimated ratio of non-transfer to the total is approximately 76%, and the ratio for one (1) transfer is 23%. The balance (two transfers) is 2%. Those figures are remarkably close to the result of interview survey, which shows 74% for non-transfer in the Central Area.

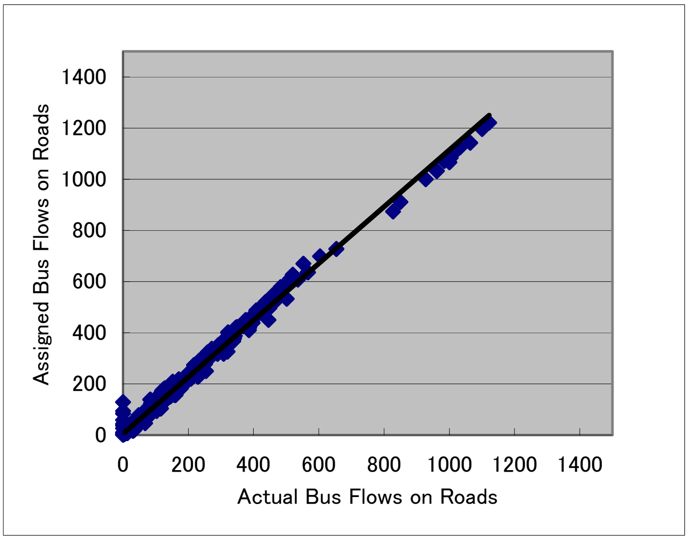


Figure 9.3-7 Comparison Between Actual Bus Flows and Estimated Flows on Roads

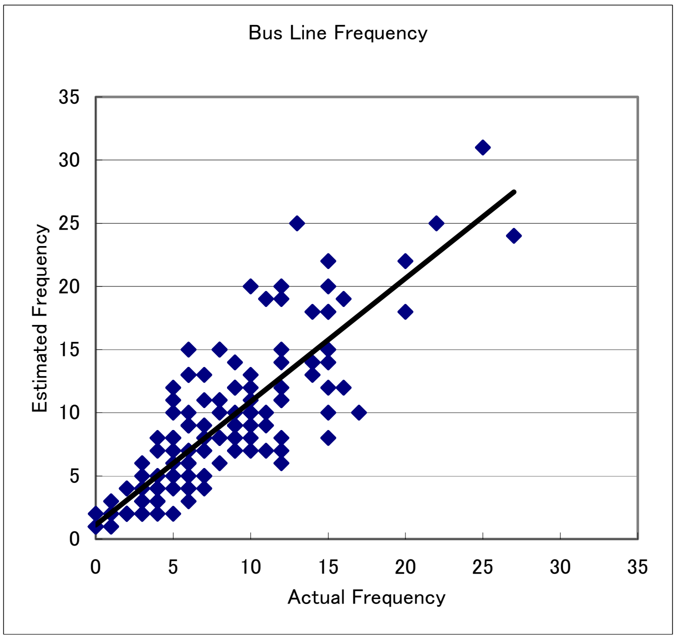


Figure 9.3-8 Comparison Between Actual Bus Frequency and Estimated Frequency by Route

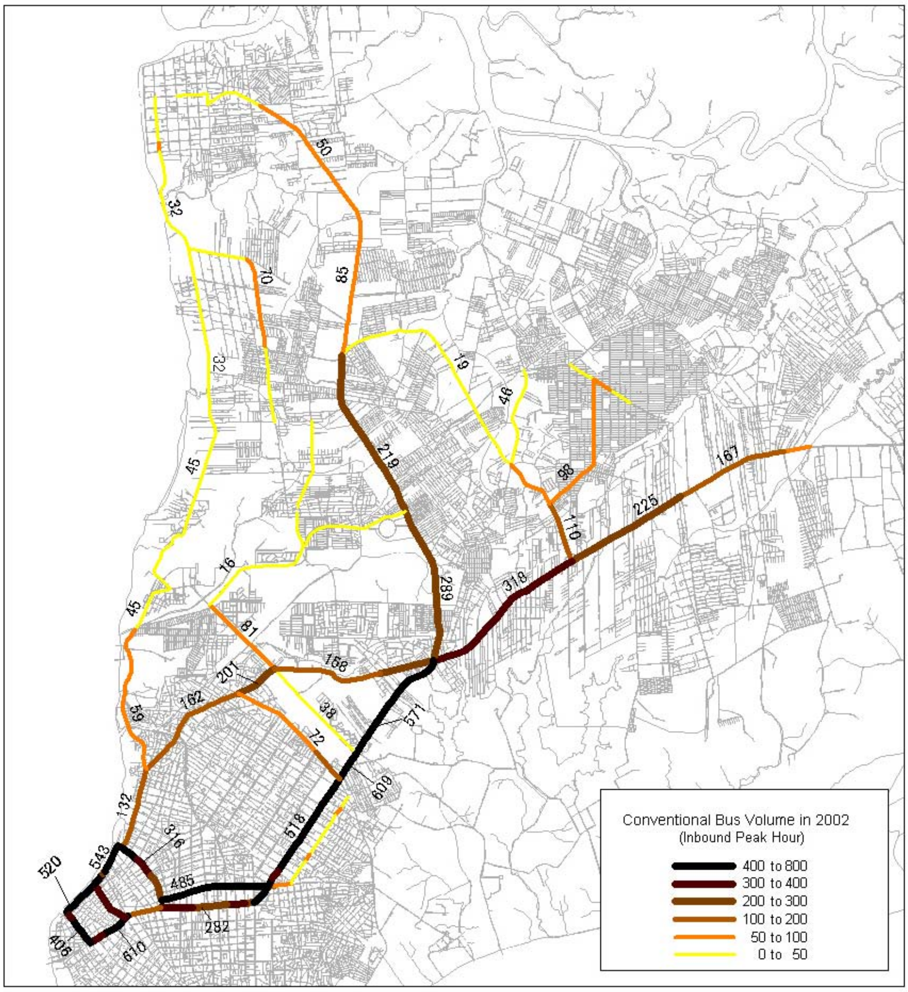


Figure 9.3-9 Assigned Peak Hour Bus Traffic Volume in 2002

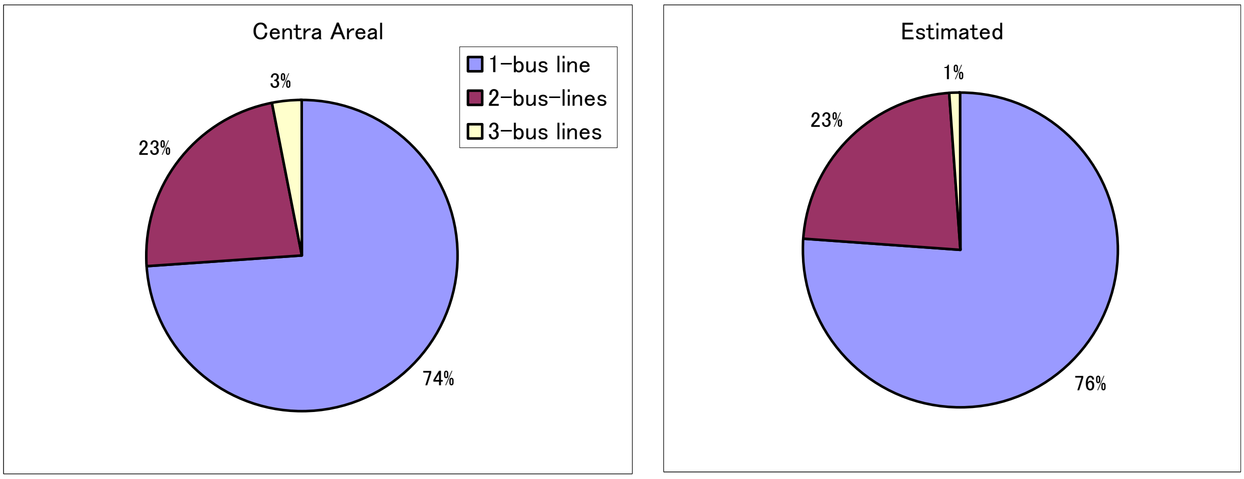


Figure 9.3-10 Surveyed and Estimated Bus Transfer Times

(3) Traffic and Transport Evaluation

In this section, traffic and transport evaluation is made in terms of traffic volume by car and bus, travel speed, and congestion (volume /capacity ratio) on the road. In order to evaluate the study projects: road and bus system projects, "With" and "Without" cases in which the study projects are executed or not, respectively, were compared. The 2002, 2007, 2012 and 2020 years' OD tables were assigned on the road and transport networks of the Short (2007), Medium (2012) and Long Term Plan (2020) projects, respectively, to evaluate traffic aspects.

Table 9.3-4 shows future road network cases. In 2007, Av. Independencia between the suburban area and Rodovia Augusto Montenegro will be prepared with six lanes in two directions, two lanes for the trunk buses and four lanes for private vehicles, while Primeiro de Dezembro will not be implemented. In 2012, the central segment on Av. Independencia will be opened with the same number of lanes as in the suburban segment, and Primeiro de Dezembro also will be prepared with four lanes. The Outer Ring Road will be added to the 2012 road network in 2020.

Table 9.3-4 Future Road Network Cases

Year	Av. Independencia		Primeiro de Dezembro	Outer Ring Road
	Central Segment	Suburban	From Primeiro Légua	
2002	×	×	×	×
2007	×	○	×	×
2012	○	○	○	×
2020	○	○	○	○

1) Traffic Volumes on Roads

Figure 9.3-11 to Figure 9.3-15 show the daily traffic volumes assigned on the above-mentioned road and bus transport network in 2002, 2007, 2012 and 2020. In those figures, the traffic volume on each road is drawn by a colored narrow band whose width is proportional to the assigned traffic volume according to the volume-capacity ratio. Black indicates the volume-capacity ratio in a range of less 1.0. The volume-capacity with over

1.5 is shown in red. Yellow indicates the middle range (1.0 <= V/C ratio <1.5). The traffic conditions in the red are severe.

In the present traffic conditions shown in Figure 9.3-11, the volume-capacity ratio exceeds 1.0 on Av. Almirante Barroso, but other major roads are less than 1.0 except for several roads in the Central Area.

Figure 9.3-12 and Figure 9.3-13 show the traffic volumes in "With" and "Without" cases in which the OD trips in 2007 loads on the present network and the 2007 network. In "Without" case, the volume-capacity ratio exceeds 1.5 on Av. Almirante Barroso, if no construction is done on Av. Independência.

In 2012, the traffic conditions will be severe on such roads as Av. Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro, if no improvements on Av. Independência and Av. Primeiro de Dezembro are made in the transport network.

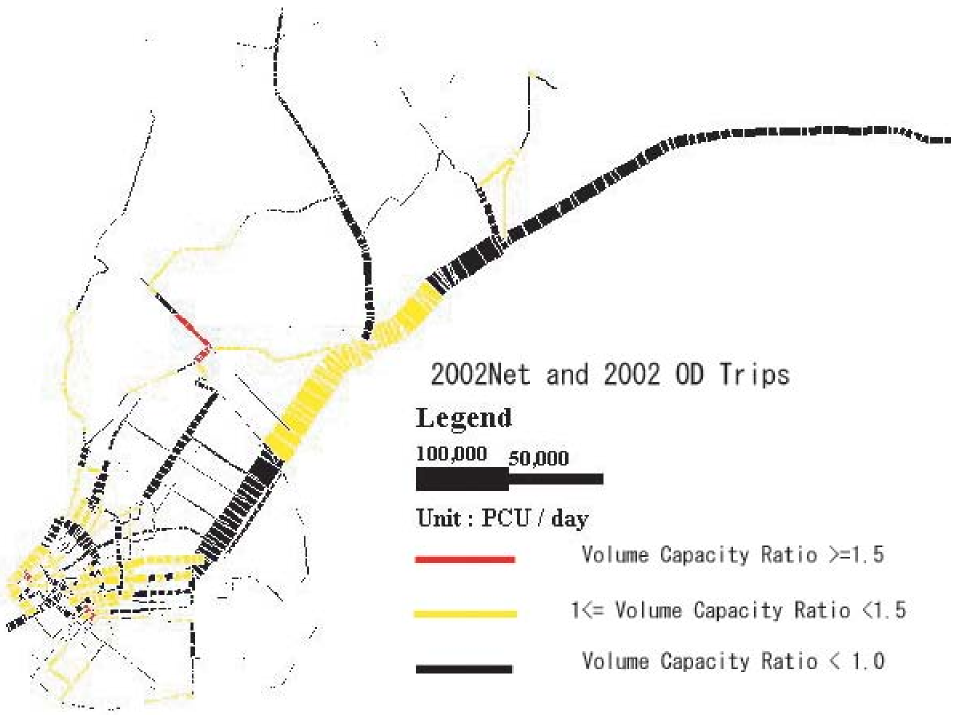


Figure 9.3-11 2002 Traffic Volume on Present Road Network

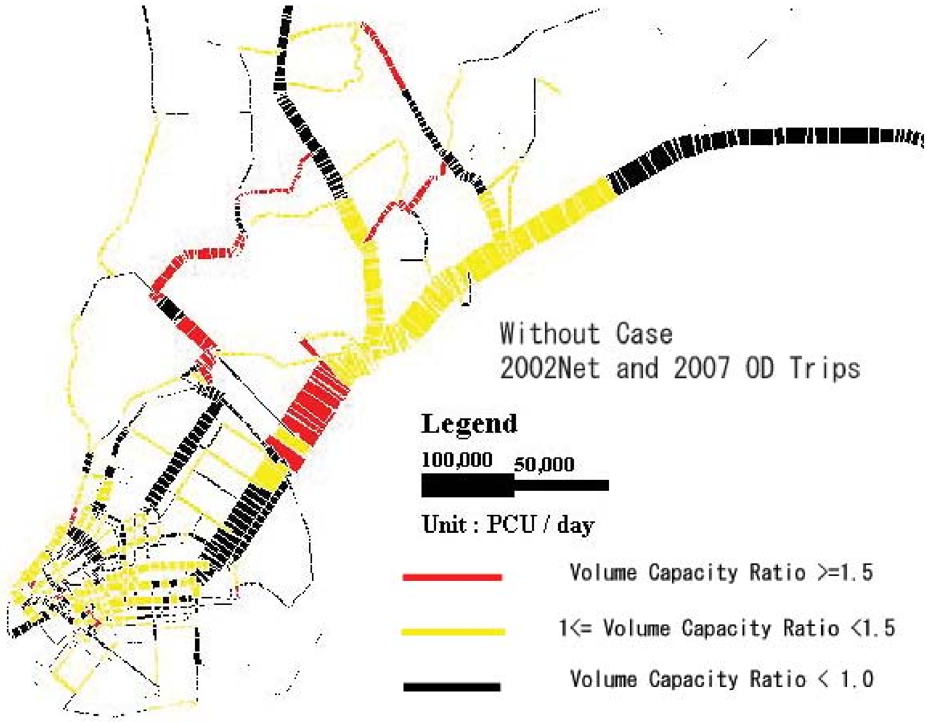


Figure 9.3-12 2007 Traffic Volume on 2002 Road Network (Without Case)

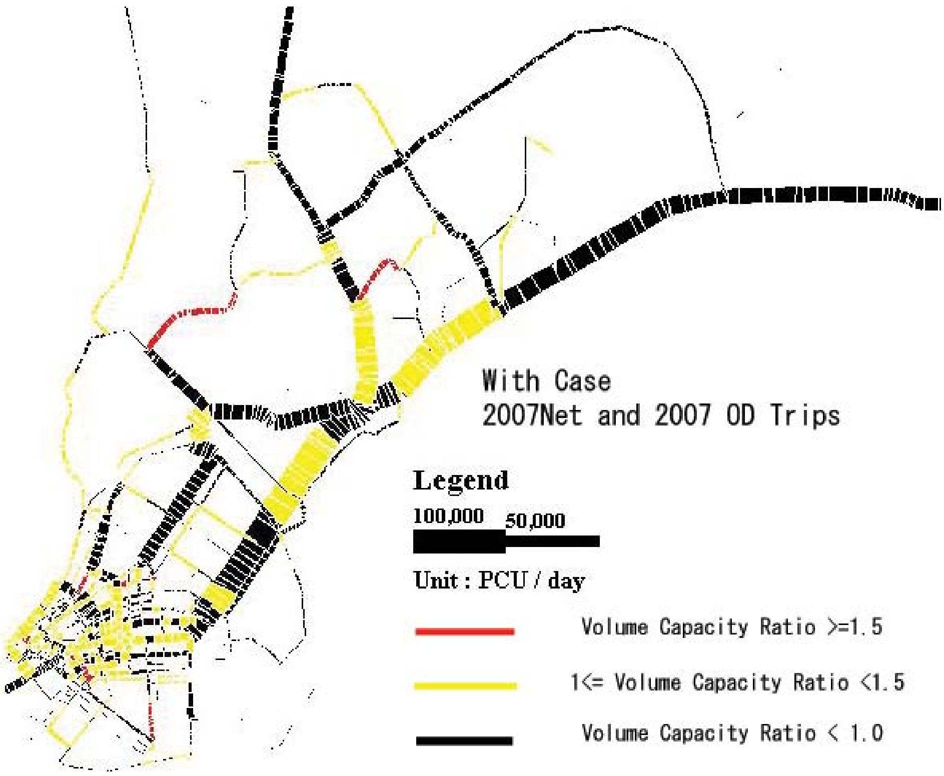


Figure 9.3-13 2007 Traffic Volume on 2007 Road Network (With Case)

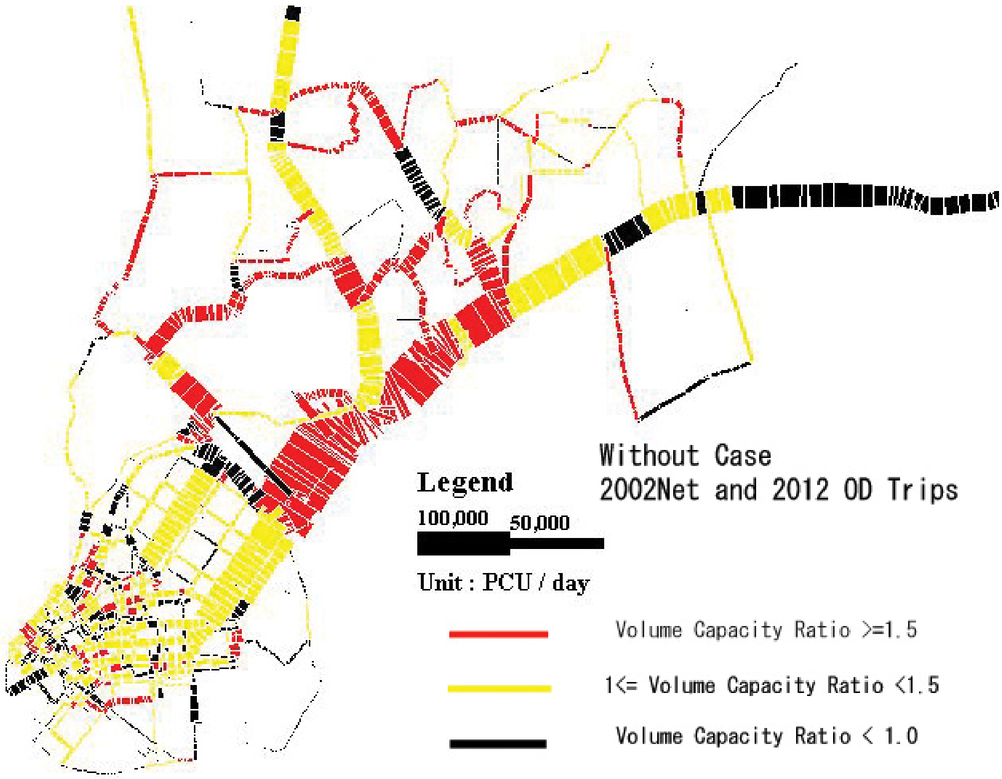


Figure 9.3-14 2012 Traffic Volume on 2002 Road Network (Without Case)

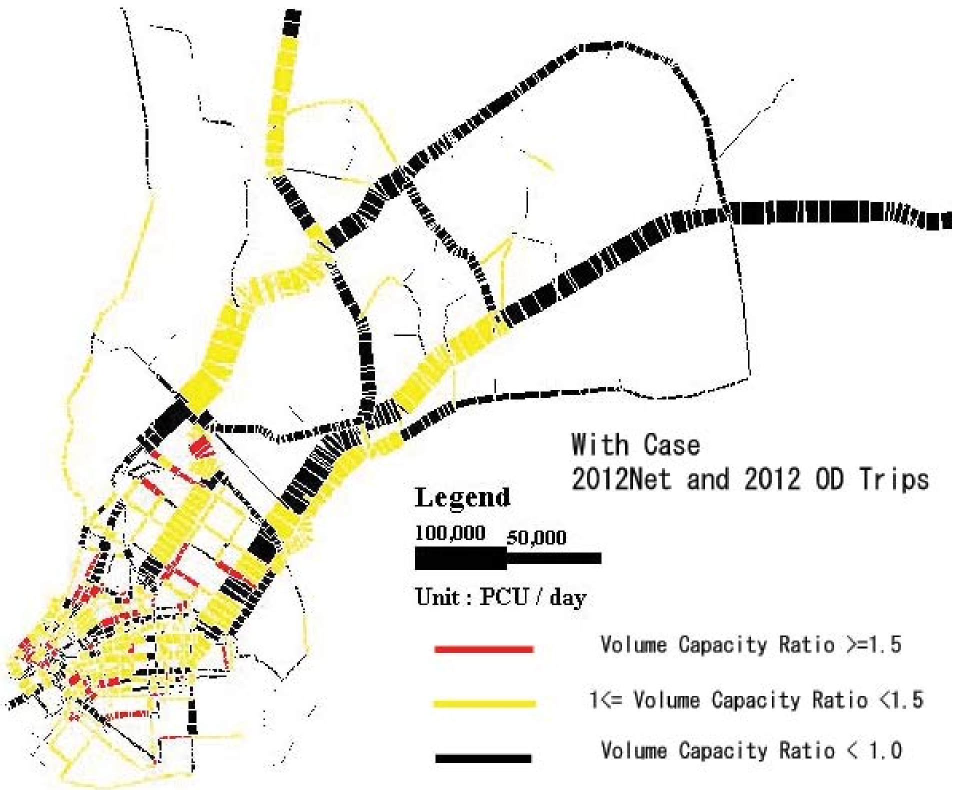


Figure 9.3-15 2012 Traffic Volume on 2012 Road Network (With Case)

2) *Vehicle-Hours*

Vehicle productivity is the product of vehicle flow and vehicle speed. The vehicle productivity can be expressed in several different units: PCU-hour, vehicle-hour, etc.

Figure 9.3-16 and Figure 9.3-17 show the rates of change by three target years in the total vehicle-hour in the study area according to "With" and "Without" cases. The bus vehicle-hour is calculated on the assumption that trunk bus operation speed is independent of traffic volume on the same roads, while the conventional bus speed is reduced in proportion to traffic volume on roads. The vehicle-hours of cars in 2012 rises 3.3 and 5.5 times in the "With" and "Without" cases, respectively, compared to the figures in 2002, while for buses the ratio in the "With" case is the same as that in 2002. This indicates that if the trunk bus system is introduced, the total bus travel time would stay at the present level, in contrast to a rise of 2.7 times in the "Without" case.

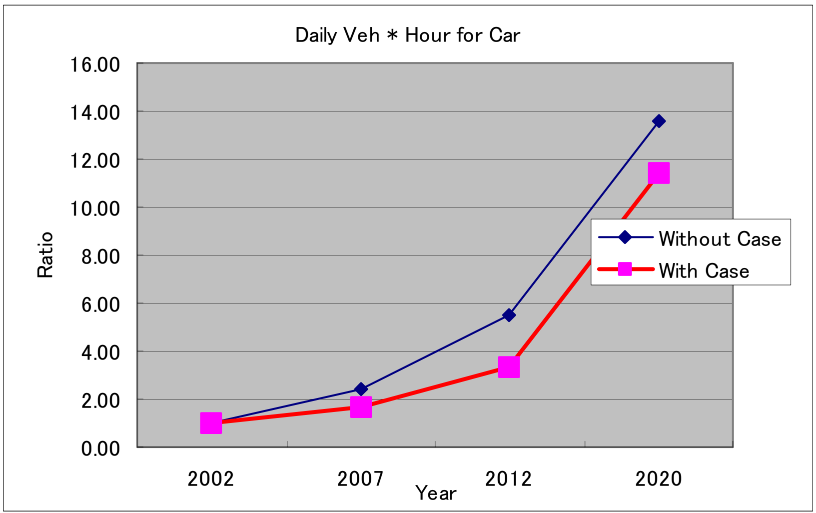


Figure 9.3-16 Ratio of Vehicle-Hours of Cars by "With" and "Without" Cases

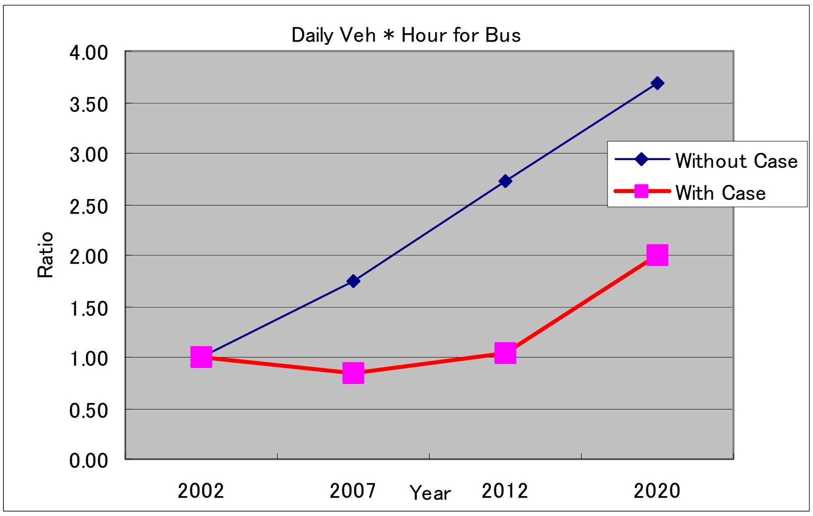


Figure 9.3-17 Ratio of Vehicle-Hour of Buses by "With" and "Without" Cases

3) *Average Travel Speed*

The peak hour average travel speeds on each road and transport facility are shown in Figure 9.3-18, which shows the average travel speed of cars and buses in the peak hour in the whole Study Area by the future target years according to the "With" and "Without" cases. The average travel speed is a typical index to show a service level. From now until 2012, they slightly decrease in the "With" case. The figures decrease from 42 km/h now to 40 km/h in 2007. In 2012, the average travel speed falls to 34 km/h, which is equivalent to 0.81 of the present. In 2020 it is obvious that the service level will be a half of the present level.

The travel speed in 2012 is dramatically different in decrease ratio to the present figure between the "With" and "Without" cases. The "Without" case stands at 0.5 times of the present while it is 0.81 for the "With" case. This indicates that the transport congestion is considerably heavier, if the "Without" case is selected.

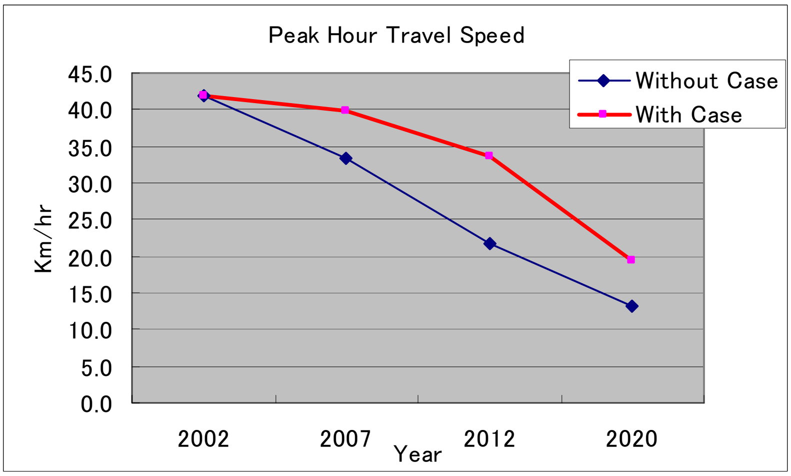


Figure 9.3-18 Peak Hour Average Travel Speed

4) *Average Volume-Capacity Ratio*

Figure 9.3-19 shows the traffic and transport congestion in terms of the average volume/capacity ratio in the peak hour in the whole study area. From 2002 until 2020, the ratio in the "With" case is slightly worse. The figure increases from 0.5 at the present to 0.75 in 2012. In 2020, the ratio rises to 1.3, which is equivalent to 2.6 times the present. It is obvious that the service level will get worse.

Comparing to the "Without" case, until 2012 the "With" case is slightly different in congestion level. After 2020, both cases diverge, and the "Without" case indicates severe congestion.

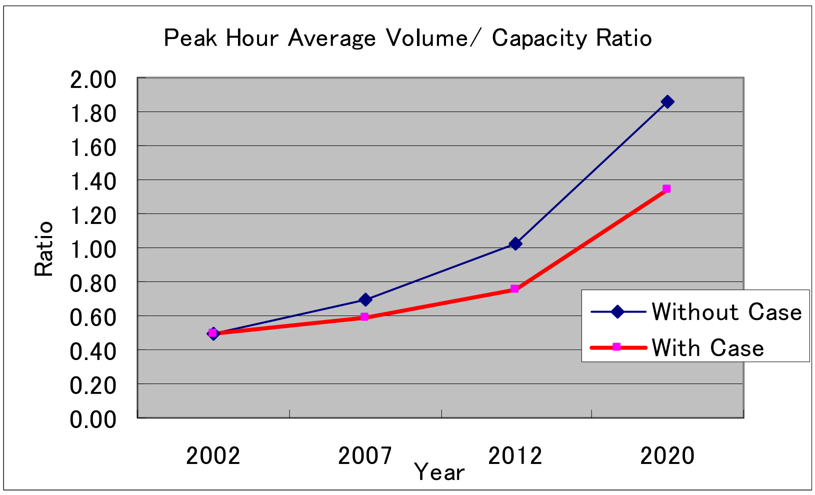


Figure 9.3-19 Peak Hour Average Volume/Capacity Ratio

9.4. FUTURE TRAFFIC VOLUME ON THE PROJECT ROADS

(1) Alternative Cases

In the Section 13.2 in Chapter 13, the preliminary road locations for the project roads were discussed in consideration of traffic, land use and environmental conditions. The final road locations on the project roads were decided. In this section, future traffic volumes on those roads were forecast to examine the number of lanes on each project road. And also, the planning schedule of those roads was identified based on the future traffic volume on those roads by several alternative cases on each target stage. The alternatives were prepared to evaluate the influence in traffic flows on project roads.

Table 9.4-1 shows the future alternative cases by year. In 2012, alternative Case-1 is set as a base case ("With" project case) in which Av. Independência is prepared with six lanes in two directions, two lanes for the trunk bus and four lanes for private vehicles, and Av. Primeiro de Dezembro also is prepared with four lanes. Case-2 is the case that plans no Av. Independência in the base case network. The influence of Av. Independência in traffic flows is disclosed in comparison with Case-1 and Case-2. Case-3 is similar to Case-2 except that Av. Independência in the central segment between the Central Area and Rodovia Augusto Montenegro will not be prepared in the base case network to evaluate the influence of no implementation on the central segment. In Case-4, Rua Yamada between Primeira Légua Patrimonial and Av. Independência is added to the base case network in which this road segment is removed from the project road. In Case-5, in order to evaluate Av. Primeiro de Dezembro, this road is removed from the Case-1 network.

In 2007, Case-6 is set as a base case in 2007 in which Av. Independência in the suburban segment is added in the present road network. In order to evaluate this road, Case-7 is set in which this road segment is removed from the road network in Case-6.

Table 9.4-1 Future Alternative Cases

Year	Case		Independencia				Pedro Miranda		1o de Dezembro		Outer Ring	Remarks
			With	Without	Central Segment	Suburban	With	Without	With	Without	With	
2012	Case-1	Base Case	O					O	O			Traget Year
	Case-2			O				O	O			Influence of Av. Independencia
	Case-3				×	O		O	O			Influence of Av. Independencia on Centro segment
	Case-4		O				O		O			Influence of Av. Pedro Miranda
	Case-5		O					O		O		Influence of Av. Primeiro de Dezembro
2007	Case-6	Base Case				O		O		O		Short Term
	Case-7			O				O		O		Influence of Av. Independencia

(2) Influence of Project Roads in 2012

1) Av. Independência

In order to evaluate the influence of the peak hour traffic flow on Av. Independencia in 2012, the difference of traffic volumes on roads between Case-2 and Case-1 was analyzed. Figure 9.4-1 shows the difference of car traffic volumes on roads, which is drawn with a colored narrow band whose width is proportional to the different traffic volume between those cases. Black indicates the traffic volume is decreased against that in Case-1, while increased traffic volume is shown with red. The bus flows, however, are not included in the traffic volume. Since a bus must be operated on a bus route, the bus cannot change the bus route according to the minimum pass route.

As can be seen, if Av. Independência is not implemented, the traffic flows pass through on its road diversion to nearby roads, which mainly include Av. Almirante Barroso (addition of a maximum of 2,500 veh/h in the peak hour), Primeiro de Dezembro (4,000 veh/h), Av. Júlio César (3,000 veh/h), Av. Pedro Álvares Cabral (2,300 veh/h), etc. Those figures are equivalent to a road capacity of 2 lanes. Therefore, the volume/capacity ratios at some segment on those roads exceed 1.5, in contrast to a ratio of less than 1.5 on Av. Almirante Barroso for Case-1.

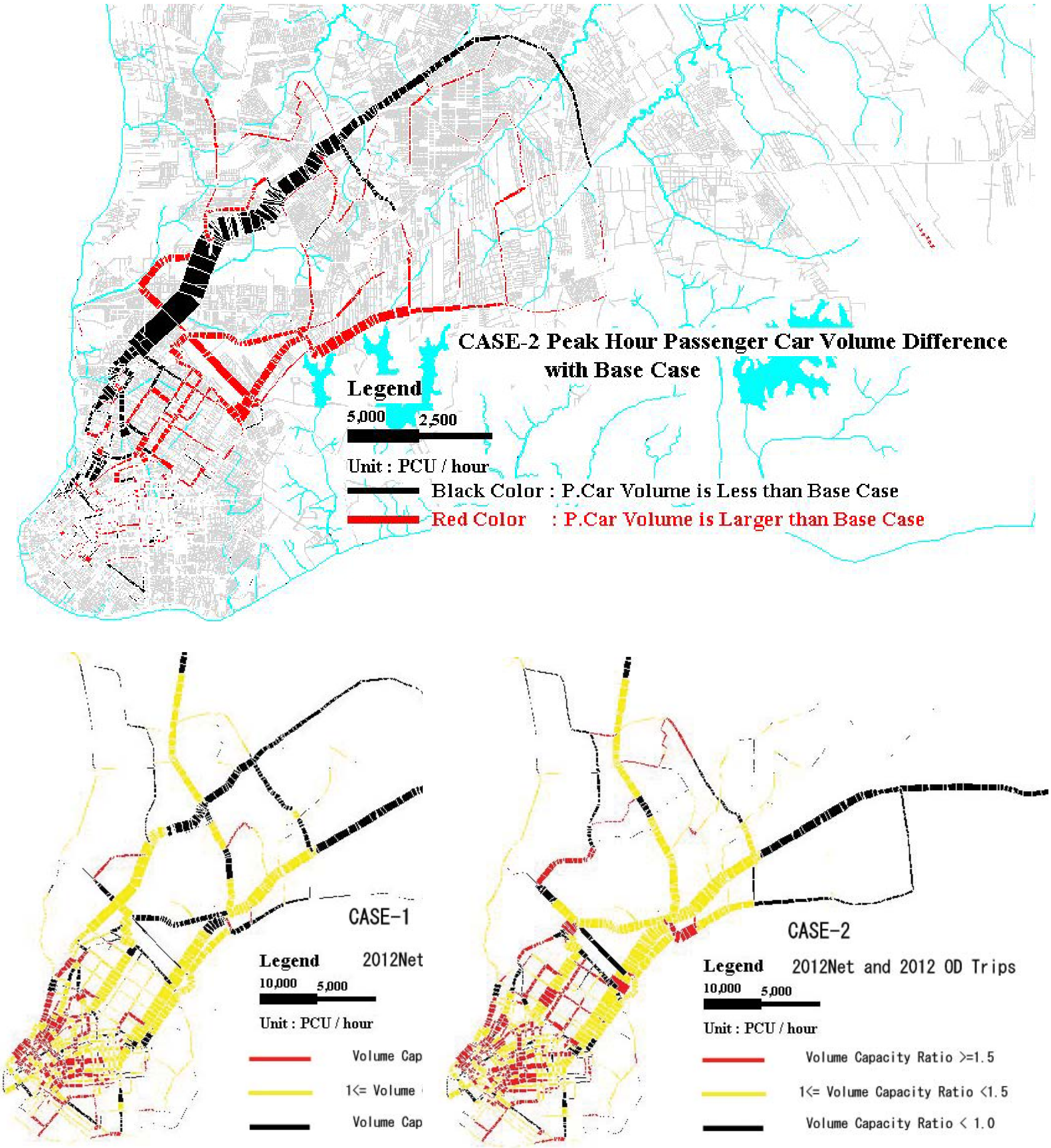


Figure 9.4-1 Difference of Traffic Volumes on Roads Between Case-2 and Case-1 in 2012

In order to evaluate the influence of the central segment on Av. Independência in 2012, the difference of traffic volumes between Case-3 and Case-1 was analyzed. Figure 9.4-2 shows the difference of car traffic volumes on roads.

As can be seen, if Av. Independência in the central segment is not implemented, the traffic flows pass through on its road divert to roads similar to those in Case-2. Those are mainly Av. Almirante Barroso (addition of a maximum of 3,000 veh/h in the peak hour), Primeiro de Dezembro (1,000 veh/h), Av. Júlio César (2,500 veh/h), and Av. Pedro Álvares Cabral (2,800 veh/h). Therefore, the volume/capacity ratios on those roads exceed 1.5. The traffic flows in both Case-2 and Case-3 are similar whether the suburban segment on Av. Independência is constructed or not. It is obvious that the suburban segment on Av. Independência does not influence traffic flows in the Central Area and its surrounding area.

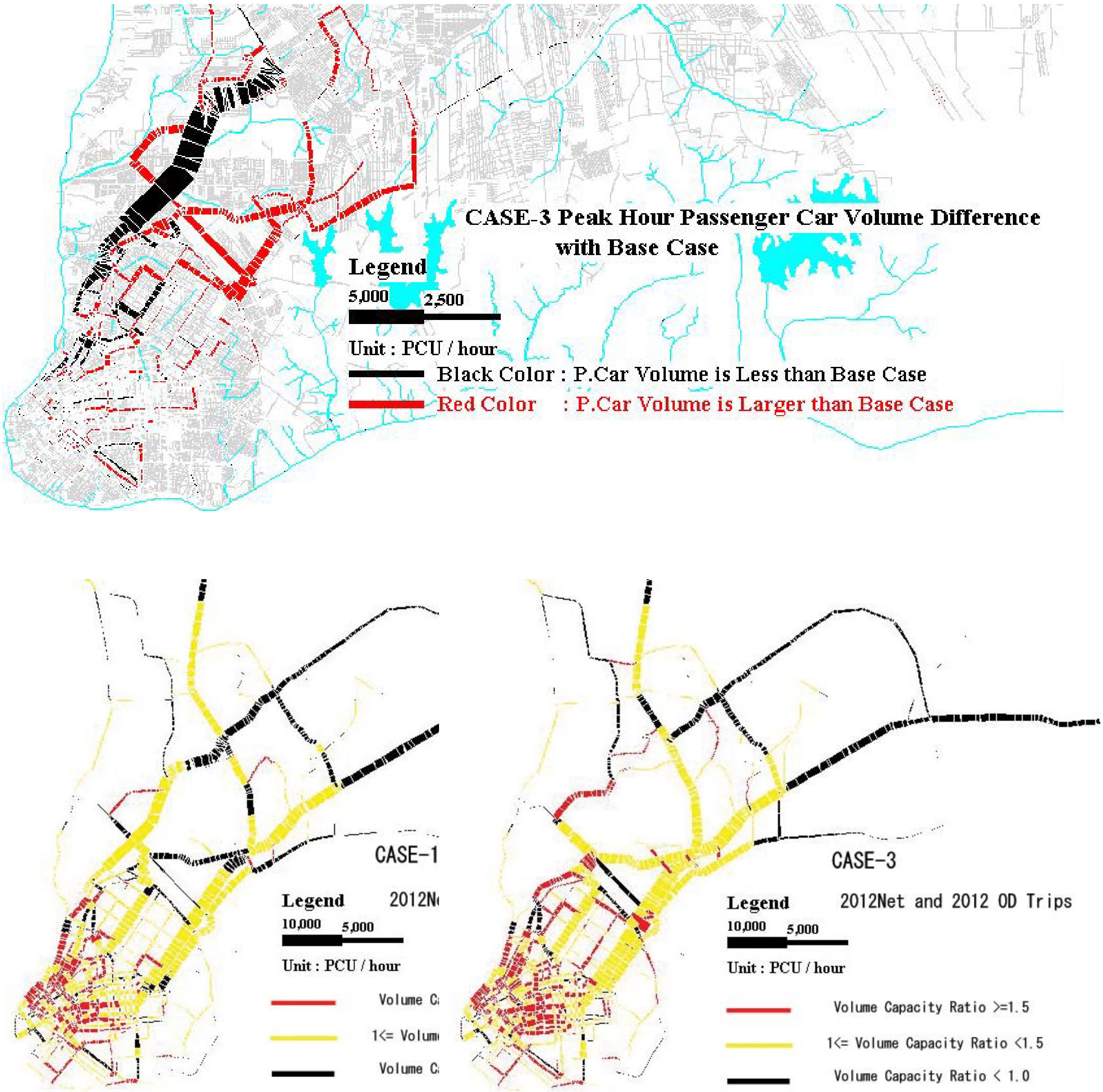


Figure 9.4-2 Difference of Traffic Volumes on Roads Between Case-3 and Case-1 in 2012

2) Rua Yamada

In order to evaluate the influence on Rua Yamada in 2012, the difference of traffic volumes on roads between Case-4 and Case-1 was analyzed. Figure 9.4-3 shows the difference of car traffic volumes on roads.

As can be seen, if Rua Yamada is implemented, the traffic volume on this road ranges from1,500 to 2,000 veh/h in the morning peak hour. On the other hand, the traffic flows on Av. Almirante Barroso (difference of a maximum of -500 veh/h in the peak hour), Primeiro de Dezembro (-300 veh/h), and Av. Júlio César (-1,000 veh/h) are decreased. It is obvious that the influence of traffic flows on Rua Yamada is low in the Central Area and its surrounding area.

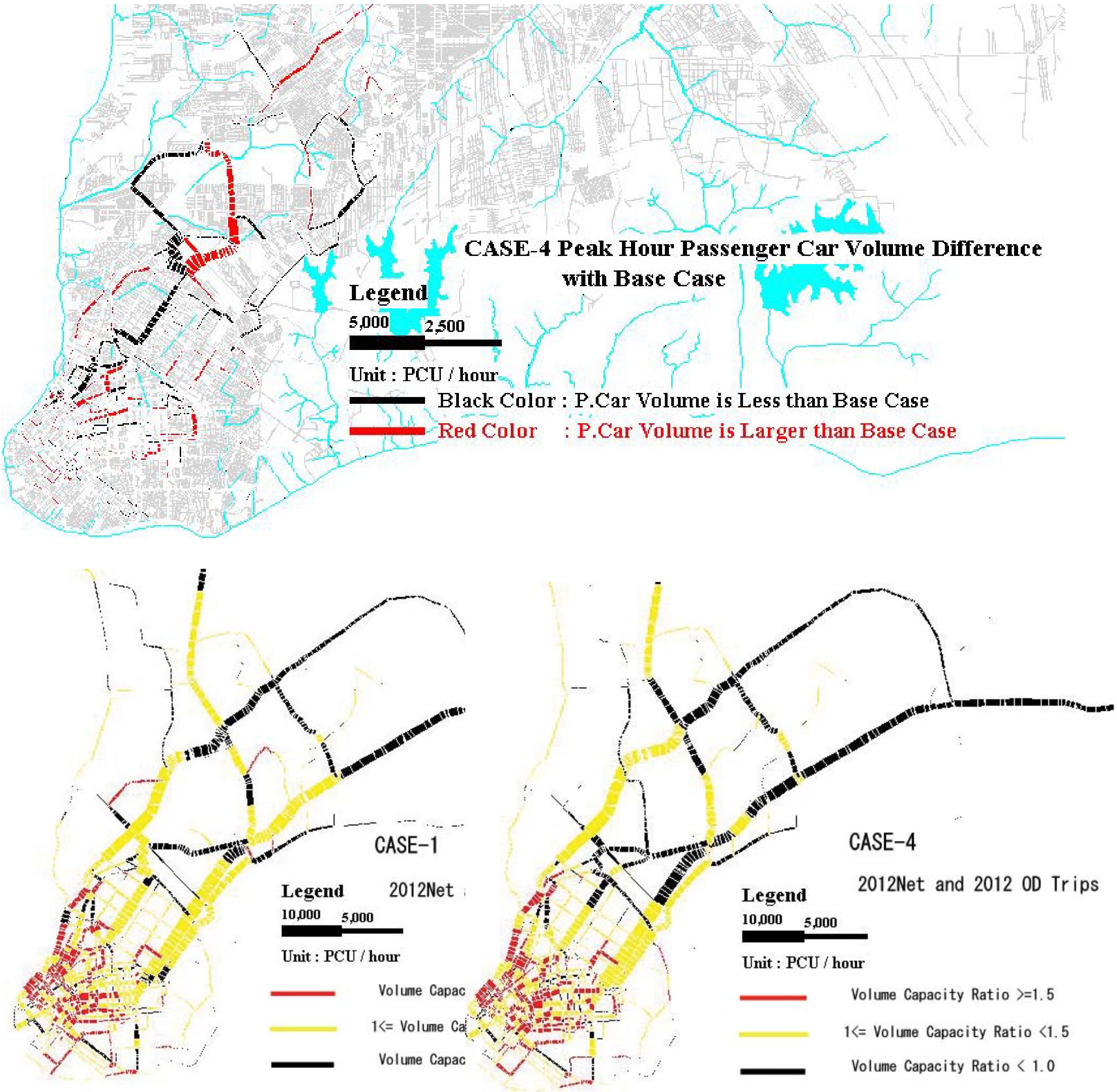


Figure 9.4-3 Difference of Traffic Volumes on Roads Between Case-4 and Case-1 in 2012

3) Primeiro de Dezembro

In order to evaluate the influence on Av. Primeiro de Dezembro in 2012, the difference of traffic volumes on roads between Case-5 and Case-1 was analyzed. Figure 9.4-4 shows the difference of car traffic volumes on roads.

As can be seen, if Av. Primeiro de Dezembro is not implemented, the traffic flows are increased on Av. Almirante Barroso (addition of a maximum of 3,000 veh/h in the peak hour), Av. Júlio César (2,500 veh/h), and Av. Pedro Álvares Cabral (2,000 veh/h). Therefore, the volume/capacity ratios on those roads exceed 1.5. Since the traffic flows on Av. Primeiro de Dezembro divert on Av. Almirante Barroso, traffic conditions on Av. Almirante Barroso are more severe. It is indispensable to construct Av. Primeiro de Dezembro by 2012.

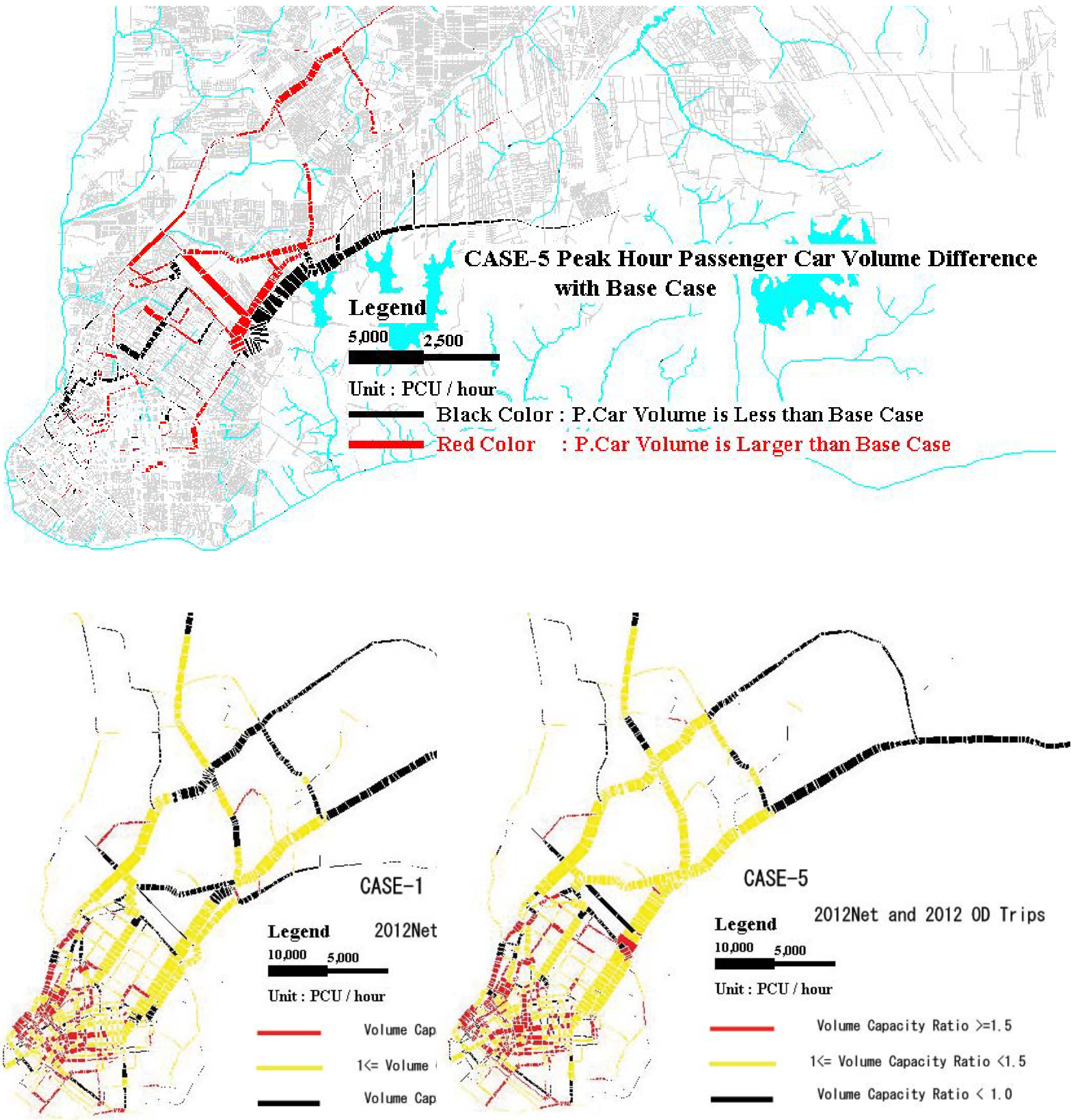


Figure 9.4-4 Difference of Traffic Volumes on Roads Between Case-5 and Case-1 in 2012

(3) Influence of Project Roads in 2007

In order to evaluate the influence of the suburban segment on Av. Independência in 2007, the difference of traffic volumes on roads between Case-7 and Case-6 was analyzed. Figure 9.4-5 shows the difference of car traffic volumes on roads.

As can be seen, if Av. Independência is not implemented, the traffic flows are mainly increased on Rodovia BR-316 (addition of a maximum of 500 veh/h in the peak hour), Rodovia Mário Covas (500 veh/h), etc. Therefore, the road length with a volume/capacity ratio of 1.5 on Av. Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro extends. Since the traffic flows on Av. Independência divert to the near suburban area, the influence on traffic flow within the Central Area is low. It is necessary to construct Av. Independência by 2007 in order to alleviate the traffic congestion on Av. Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro.

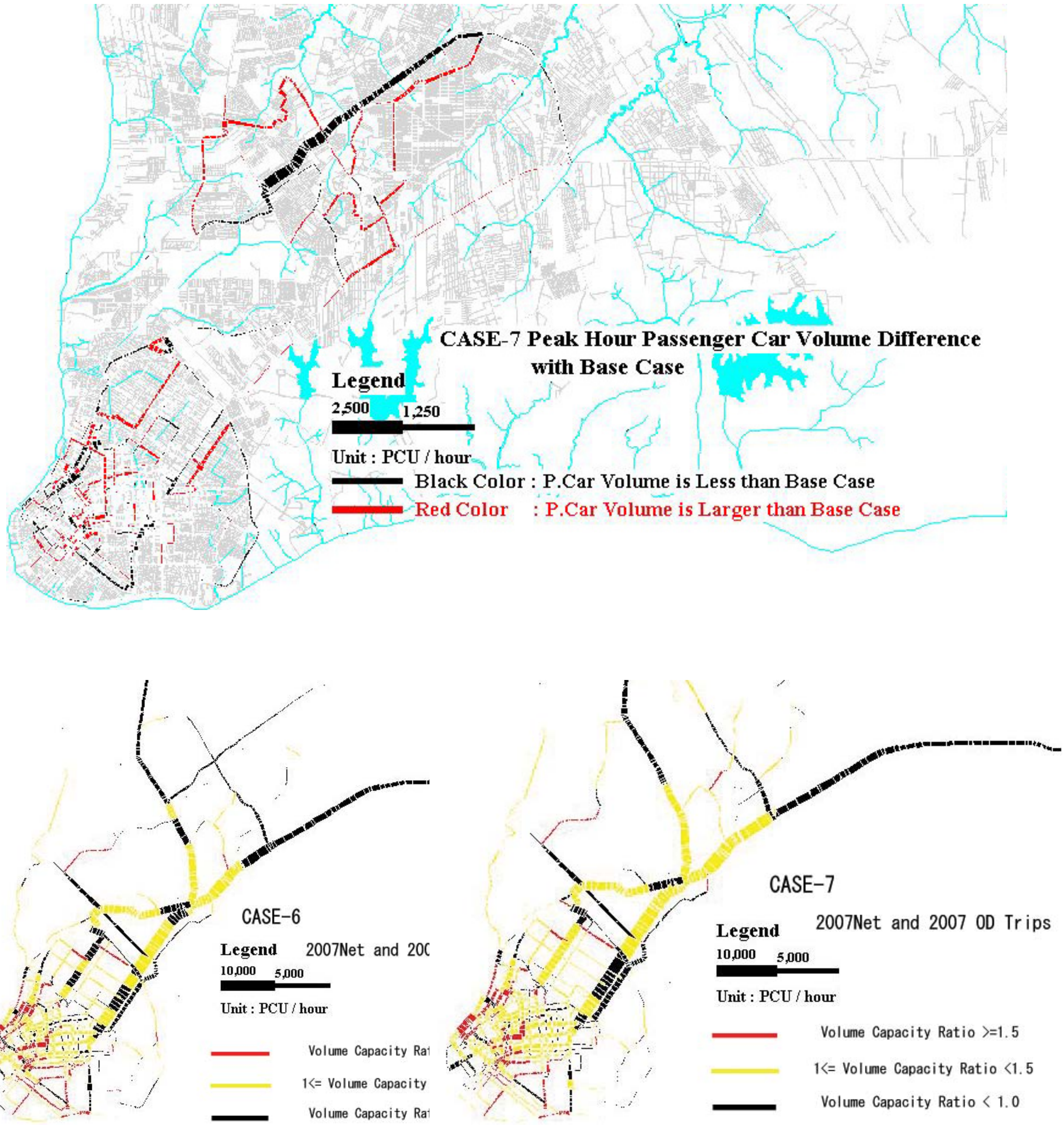


Figure 9.4-5 Difference of Traffic Volumes on Roads Between Case-7 and Case-6 in 2007