Japan International Cooperation Agency (JICA)
The Government of State of Para
The Federative Republic of Brazil

The Feasibility Study On The Improvement of Transport System In The Metropolitan Area of Belem In The Federative Republic of Brazil

Final Report (Summary)

October 2003

Chodai Co., Ltd
In Association With
Yachiyo Engineering Co., Ltd

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US$ 1.00 = Real$ 2.90

US$ 1.00 = ¥120

Preface

In response to a request from the Government of the Federative Republic of Brazil, the Government of Japan decided to conduct the Feasibility Study on the Improvement of Transport System in the Metropolitan Area of Belem in the Federative Republic of Brazil and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Kenichi Sekine of Chodai Co., Ltd., to Brazil, three times between May 2002 and August 2003. In addition, JICA set up an advisory committee headed by Dr. Koshi Yamamoto, Professor, University of Nagoya Institute of Technology between May 2002 and August 2003, which examined the study from specialist and technical points of view.

The Team held discussions with the officials concerned of the Government of the Federative Republic of Brazil, and conducted a field survey at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Federative Republic of Brazil for their close cooperation extended to the team.

October 2003

Kazuhisa Matsuoka
Vice President
Japan International Cooperation Agency

Letter of Transmittal

October 2003

Mr. Kazuhisa Matsuoka
Vice President
Japan International Cooperation Agency

Dear Sir.

It is a great honor for me to submit herewith the final reports of the Feasibility Study on the Improvement of Transport System in the Metropolitan Area of Belem in the Federative Republic of Brazil.

A study team, which consists of Chodai Co., LTD. and Yachiyo Engineering Co., LTD. and headed by myself, conducted field surveys, data analysis and planning works of feasibility study in Belem based on the terms of references instructed by the Japan International Cooperation Agency (JICA) from May 2002 to August 2003.

The study team held thorough discussions and investigations with officials concerned of the Government of the Federative Republic of Brazil, accordingly, various traffic surveys, present condition analysis, preliminary engineering design, conduct of environmental impact assessment, preparation of implementation program and project evaluation. The results were collected in the final reports, main and summary reports.

On behalf of the team I wish to express my heartfelt appreciation to the Officials concerned of the Government of the Federative Republic of Brazil for their warm friendship and cooperation extended to us during our stay in Brazil.

Also, I wish to express my sincere appreciation to JICA, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, the Embassy of Japan in Brazil and other concerned government authorities for their valuable advice and cooperation given to us in the course of the site surveys and preparation of the final reports.

Yours Faithfully,

Kenichi Sekine

Team Leader

The Feasibility Study on the Improvement of Transport System in the Metropolitan Area of Belem in the Federative Republic of Brazil

The Feasibility Study
on the Improvement of Transport System
in the Metropolitan Area of Belem

Study Duration: May 2002 – October 2003
Requesting Organization: Para State

Outline of the Study

1. STUDY BACKGROUND

In 2000, the Government of the Federative Republic of Brazil (hereinafter referred to as "GOB") requested the Government of Japan (hereinafter referred to as "GOJ") for assistance to carry out "the Update of Master Plan for Urban Transport in the Metropolitan Area of Belem" (hereinafter referred to as "PDTU2001") and the study was completed in 2001 by joint efforts of the Brazilian and the Japanese study team.

PDTU2001 recommended a new bus system and a number of road projects as high priority projects, by noting the importance of strengthening the public transport system and the urban road network in the Belem Metropolitan area (BMA). The further study of the proposed bus system and road projects is essential to put the Master Plan into effect. Therefore, the GOB requested assistance from the GOJ for the conduct of the Study related to PDTU2001.

The GOJ has decided to conduct the "Feasibility Study on the Improvement of Transport System in the Metropolitan Area of Belem" (hereinafter referred to as "the Study") following PDTU2001. The Study was commenced in May 2002 and will complete in October 2003.

2. STUDY OBJECTIVES

The objectives of the Study are as follows:

1) To undertake feasibility study on the improvement of transport system, which contains the road projects and the bus system project, both of which are necessary to mitigate the inefficiency of the present transport system in the Metropolitan Area of Belem, and,
2) To pursue technology transfer to Brazilian counterparts in the course of the implementation of the Study.

3. STUDY AREAS

The Study covers the bus system and road projects in the Metropolitan Area of Belem. The bus system project is composed of road infrastructure, integrated bus terminals and bus operation system.

As for the road project, five (5) roads are included as a study road: Av. Primeiro de Dezembro, Av. Independencia, Av. Pedro Miranda, Rua da Marinha, and Link road of Cidade Nova to Av. Primeiro de Dezembro.

The year 2012 is defined as the target year for feasibility study.

4. STUDY DURATION

The Study was commenced in May 2002 and will complete in October 2003.

5. OUTLINE OF STUDY

(1) Bus Operation System

The trunk bus operation consists of three system components: namely, (i) trunk bus system, (ii) feeder bus system and (iii) conventional bus system. Taking into account the different busway facilities conditions, the proposed trunk bus system runs on three types of busways: viz., (i) trunk busways, (ii) exclusive trunk busways and (iii) trunk bus priority lanes. A feeder bus system is provided for relatively short rides to collect passengers to each trunk bus terminal with integrated transfer. The trunk bus system replaces 61 conventional bus lines, and the remaining 104 bus lines continue their conventional service.

(2) Integrated Bus System

The present study proposes eight new bus terminals for trunk bus operation. Each terminal provides integrated transfers between feeder and trunk bus lines. In this proposal, conventional bus lines will not be integrated with the trunk bus system. Accordingly, eight bus terminals will be so structured to segregate the integrated feeder and trunk bus services from the conventional bus lines and other private transport means. Passengers of conventional bus lines can transfer to trunk bus lines at trunk bus stops but they have to pay the fare again. Passengers of a trunk bus line also have to pay the fare whey they transfer to another trunk bus line (A bus zone to/from B bus zone) at a trunk bus stop.

(3) Bus Infrastructure

In order to ensure the smooth and effective operation of the trunk bus service, the study proposes the following infrastructure development. Table 1 shows the project dimension such as type of busway, length, and number of lanes.

1) *Two-way trunk busways* are constructed on the central part of three existing trunk roads, namely, Rodovia BR-316, Avenida Almirante Barroso and Rodovia Augusto Montenegro. In conjunction, the available roadways, bikeways and sidewalks of the three roads are structurally improved.
2) Avenida Independencia, two-way four-lane road now under construction, is widened to a six-lane road with *the two-way exclusive trunk bus lanes* provided on its median.
3) Along a number of roads within Belem and Icoaraci Cities and Rodovia Mario Covas in Cidade Nova, an outermost lane on each side is improved as *trunk bus priority lane*, marked by colored asphalt concrete pavement.
4) Avenidas Pedro Cabral and Senador Lemos, currently serving two-way traffic with dual carriageway, are converted to one-way roads with three lanes, with the remaining lane improved as trunk bus priority lane, similarly marked by colored asphalt concrete pavement.
5) Integrated bus terminals are newly constructed at eight locations.
6) New bus stops are constructed along trunk busways and exclusive trunk bus lanes.

(4) Road Projects

Four (4) road projects are planned in the study, which are: new construction of Av. Independencia (Para State is now constructing the suburban segment and is planning the

Centro accessing segment in this study), extension and new construction of Primeiro de Dezembro, and improvement of Rua Yamada and Rua da Marinha.

Road design of the road projects is examined taking into account the conservation of natural and social environment. The adjustment of construction year of trunk bus and road projects in the implementation plan is made from the viewpoint of the travel demand on both road and trunk bus facilities.

From the viewpoints of the bus travel demand, the implementation of the Centro accessing segment of Avenida Independencia by 2010 is indispensable. Primeiro de Dezembro should be constructed by 2010 as well as that of Avenida Independencia. On the other hand, road constructions on Rua Yamada and Rua da Marinha will be recommended in 2012 as a middle term project. Table 2 shows the project dimension such as road length and number of lanes.

(5) Project Cost and Financial Resource

The total investment of the trunk bus and road projects as shown in Table 1 and Table 2 is estimated at US$261 million, of which US$163.0 million, equivalent to 62% of the total, is estimated for the trunk bus projects and US$98.5 million is for the road projects. The investment of the trunk bus projects will peak in 2006 when the busways are constructed. Its cost is approximately US$82 million. The economic viability of the project is very high showing 28.0 % of E-IRR and R$495 million of NPV. If evaluating the trunk bus system project alone, the economic E-IRR is 17.0%. The E-IRR of the entire road project is extremely high at 41%. As for financial analysis, the project F-IRR is very high at 40.9% and Equity IRR is 20.3%

Comparatively, these investments apparently exceed the budget of infrastructure in Para State. For an early implementation stage of the projects, certain financial resources should be identified as soon as possible.

Table 1 Recommended Trunk Bus Project

No.	Project Name	Type of Busway	Project Length (km)	No. of Bus Lane (/direction)	Project Cost (1000US$)
1. Busway Projects					
1)	Av. Almirante Barroso	Trunk Busway	6.000	2	17,885
2)	Rodovia BR-316	Trunk Busway	10.750	2	32,438
3)	Rodovia August Montenegro	Trunk Busway	13.635	2	34,651
4)	Av. Independencia on the Suburban Segment	Exclusive Trunk Bus Lane	12.344	2	24,241
5)	Av. Independencia on the central accessing Segment	Exclusive Trunk Bus Lane	7.235	2	21,550
6)	Bus Priority Road from Icoaraci Bus Terminal to Rodovia Augusto Montenegro	Trunk Bus Priority Lane	3.270	2	496
7)	Bus Priority Road from Sao Braz Bus Terminal into Centro	Trunk Bus Priority Lane	9.800	2	2,142
8)	Bus Priority Road on Avenida Pedro Cabral and Senador Lemos	Trunk Bus Priority Lane	7.800	2	11,855
9)	Rodovia Mario Covas in Cidade Nova	Trunk Bus Priority Lane	3.550	2	1,224
	Sub-Total		74.384		146,482
2. Integrated Bus Terminals			Area m2		
1)	Terminal A: Icoaraci	Bus Terminal	11,480		1,454
2)	Terminal B: Tapana	Bus Terminal	15,540		2,091
3)	Terminal C: Mangueirao	Bus Terminal	15,540		2,010
4)	Terminal D: Coqueiro	Bus Terminal	18,768		2,294
5)	Terminal E: Aguas Lindas	Bus Terminal	9,680		1,238
6)	Terminal F: Marituba	Bus Terminal	16,770		2,187
7)	Terminal G: Independencia 1	Bus Terminal	10,560		1,117
8)	Terminal H: Independencia 2	Bus Terminal	10,560		1,071
	Sub-Total				13,462
			Number		
3. Bus Facilities (Bus Stops)		Bus Stop	45		3,023
		Bus Shelter	82		
		Sao Braz Terminal Rehabilitaion	1		
4. Total Cost of Trunk Bus System Project					162,967

Table 2 Recommended Road Project

No.	Project Name	Project Length (km)	No. of Lane (/direction)	Project Cost (1000US$)	Remarks
1)	Av. Independencia on the Suburban Segment	12.344	4	39,360	Constructing by Para State
2)	Av. Independencia on the central accessing Segment	7.235	4	37,276	Planning by Para State
3)	Av. Primeiro de Dezembro/Rodovia Mario Covas Extension	10.077	4	51,795	New construction road
4)	Rua Yamada	10.000	4	32,655	Road Improvement
5)	Rua da Marinha	4.555	4	14,051	Road Improvement
Sub-Total excluding Av. Independencia		24.632		98,501	Only Stury Projects
Total		44.211		175,137	

(6) Benefits to Environmental Conservation

1) Environmental Conservation

The trunk bus system uses the available road space of the existing trunk roads. Because the widening of road space is not required, the proposed system is unlikely to do additional damage to the current situation of the surrounding environment. Nonetheless, it is necessary to take sufficient environmental conservation measures both during and after the construction.

2) Reduced Emission of Nitrogen Oxides (NO_X)

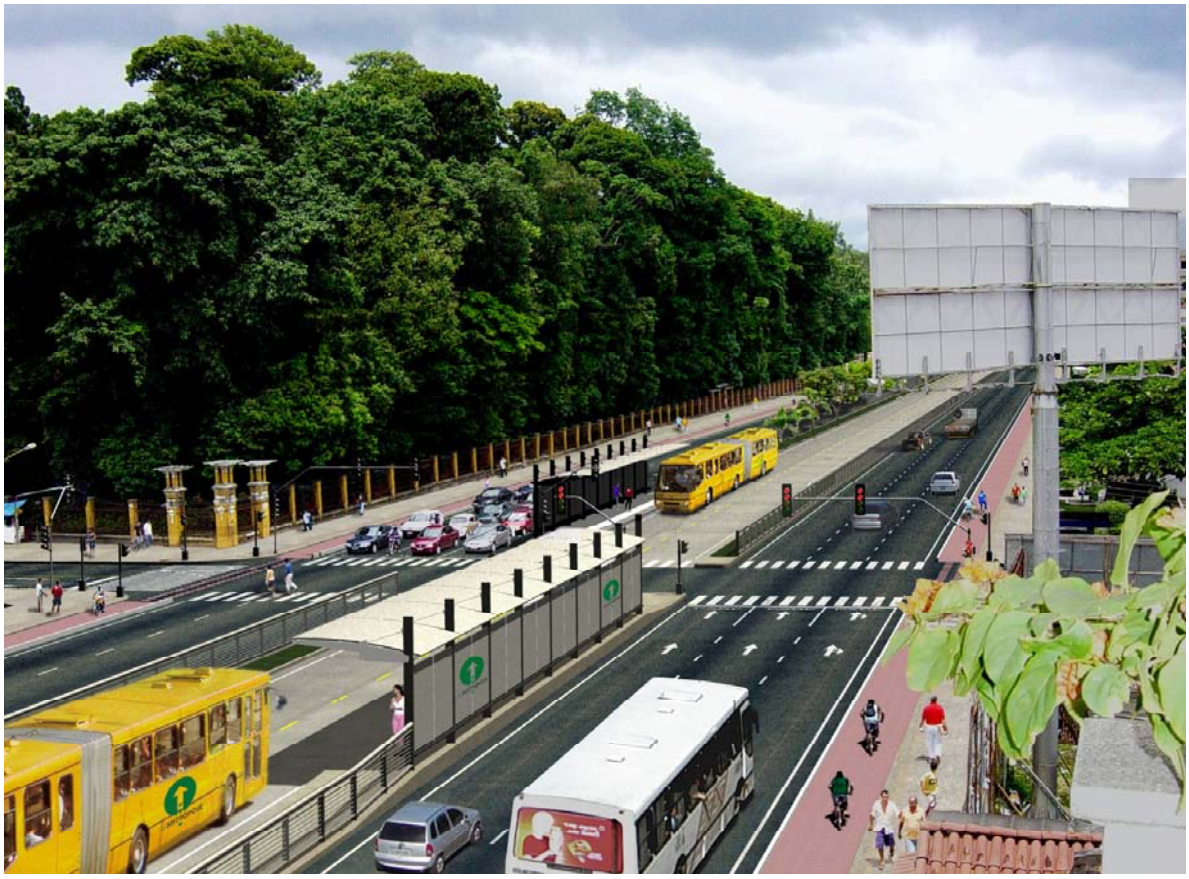
The level of air pollution by NO_X, CO, PM-10 and SO_2 in the study area is currently better than the national environmental standards. However, the situation is sure to deteriorate in the foreseeable future. Without the trunk bus system, the daily emission of NO_X will rise to 12.6 tons in 2007 and 18.5 tons in 2012. With the system, the NO_X emission will be 11.2 and 14.9 tons respectively, lower by 10% and 20% relative to the "without" situation. The introduction of the trunk bus system will be effective to keep the air pollution by NO_X in check.

3) Reduced Emission of Carbon Dioxide (CO_2)

Without the trunk bus system, the daily emission of CO_2 is estimated to reach 1,590 tons in 2007 and 2,850 tons in 2012. With the system, the daily emission will be 1,380 and 2,110 tons, lower by 13 and 26% respectively relative to the "without" situation. The trunk bus system will serve sizably to curtail the CO_2 emission, the major cause of global warming.

4) Expropriation Program

Based on the basic design of the proposed road and bus system project, the number of house to be expropriated was estimated, and it was found that approximately 1,818 houses must be expropriated within this project. Among of them, 601 families will move into resettlement sites. Within this project, the Government of Para State will prepare nine resettlement sites around the project area.



Photomontage for Trunk Busway on Avenida Almirante Barroso

Photomontage for Trunk Busway on Rodovia BR-316

Photomontage for Trunk Busway on Rodovia Augusto Montenegro

Photomontage for Exclusive Trunk Bus Lane on Avenida Independencia

Photomontage for Trunk Bus Priority Lane in Central Area

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1. INTRODUCTION

1.1. BACKGROUND OF THE STUDY

The "Master Plan Study on Urban Transport in Belem" (hereinafter referred to as "PDTU1991") was carried out by JICA in 1991, but the proposed projects were not implemented on schedule because of the reorganization in the executing agencies such as EBTU and EMTU. In 2000, the Government of the Federative Republic of Brazil (hereinafter referred to as "GOB") requested the Government of Japan (hereinafter referred to as "GOJ") for assistance to carry out "the Update of Master Plan for Urban Transport in the Metropolitan Area of Belem" (hereinafter referred to as "PDTU2001") and the study was completed in 2001 by joint efforts of the Brazilian and the Japanese study team.

PDTU2001 recommended a new bus system and a number of road projects as high priority projects, by noting the importance of strengthening the public transport system and the urban road network in the BMA. The further study of the proposed bus system and road projects is essential to put the Master Plan into effect. Therefore, the GOB requested assistance from the GOJ for the conduct of the Study related to PDTU2001, as a technical cooperation programs of the GOJ.

In response to the request from the GOB, the GOJ has decided to conduct the "Feasibility Study on the Improvement of Transport System in the Metropolitan Area of Belem" (hereinafter referred to as "the Study") following PDTU2001. The Study was carried out in 2002 and 2003.

1.2. STUDY OBJECTIVES

The objectives of the Study are as follows:

1) To undertake feasibility study on the improvement of transport system, which contains the road projects and the bus system project, both of which are necessary to mitigate the inefficiency of the present transport system in the Metropolitan Area of Belem, and,

2) To pursue technology transfer to Brazilian counterparts in the course of the implementation of the Study.

1.3. STUDY AREAS/ STUDY PROJECTS

The Study covers the bus system and road projects in the Metropolitan Area of Belem, shown in Figure 1-1 . The bus system project is composed of road infrastructure, integrated bus terminals and bus operation system. The projects of road infrastructure cover the following five (5) bus roads: Marituba - Sao Braz, Icoaraci – Entroncamento, BR-316 – Cidade Nova, Central Area, and Binary Av. Pedro Alvares Cabral and Av. Senador Lemos. The bus terminal projects also cover the four (4) terminals: Terminal Marituba, Terminal Cidade Nova, Terminal Icoaraci, and Terminal Sao Braz (Renovation). The bus operation projects include re-organization of bus network by the introduction of trunk routes, electronic ticket system, and new tariff system.

As for the road project, five (5) roads are included as a study road: Av. Primeiro de Dezembro, Av. Independencia, Av. Pedro Miranda, Rua da Marinha, and Link road of Cidade Nova to Av. Primeiro de Dezembro.

1.4. TARGET YEAR

The year 2012 is defined as the target year for feasibility study.

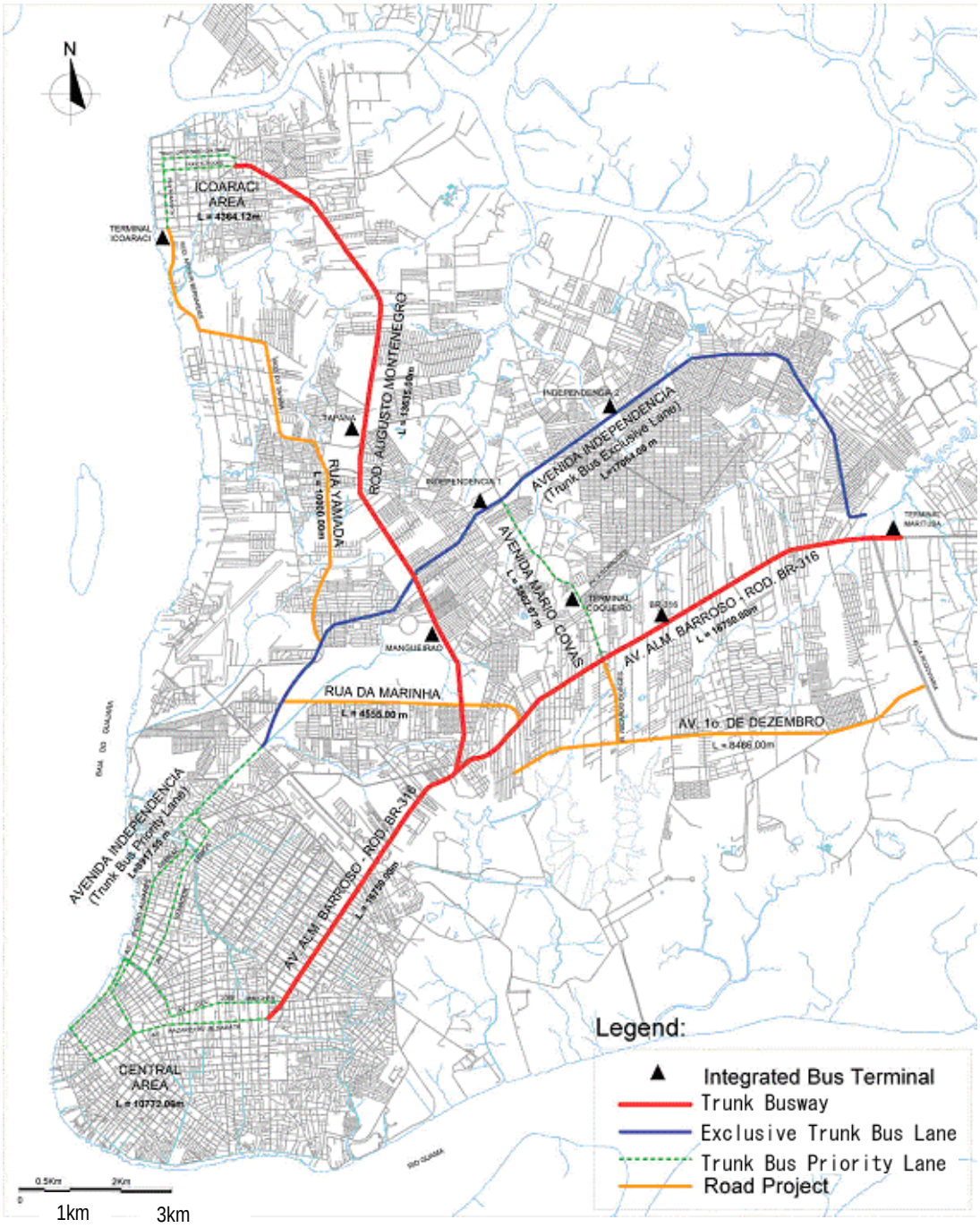


Figure 1-1 Study Area and Study Projects

1.5. SCOPE OF STUDY

Major activities of the Study are divided into four (4) stages and the schedule of the stages is as shown in Figure 1-2.

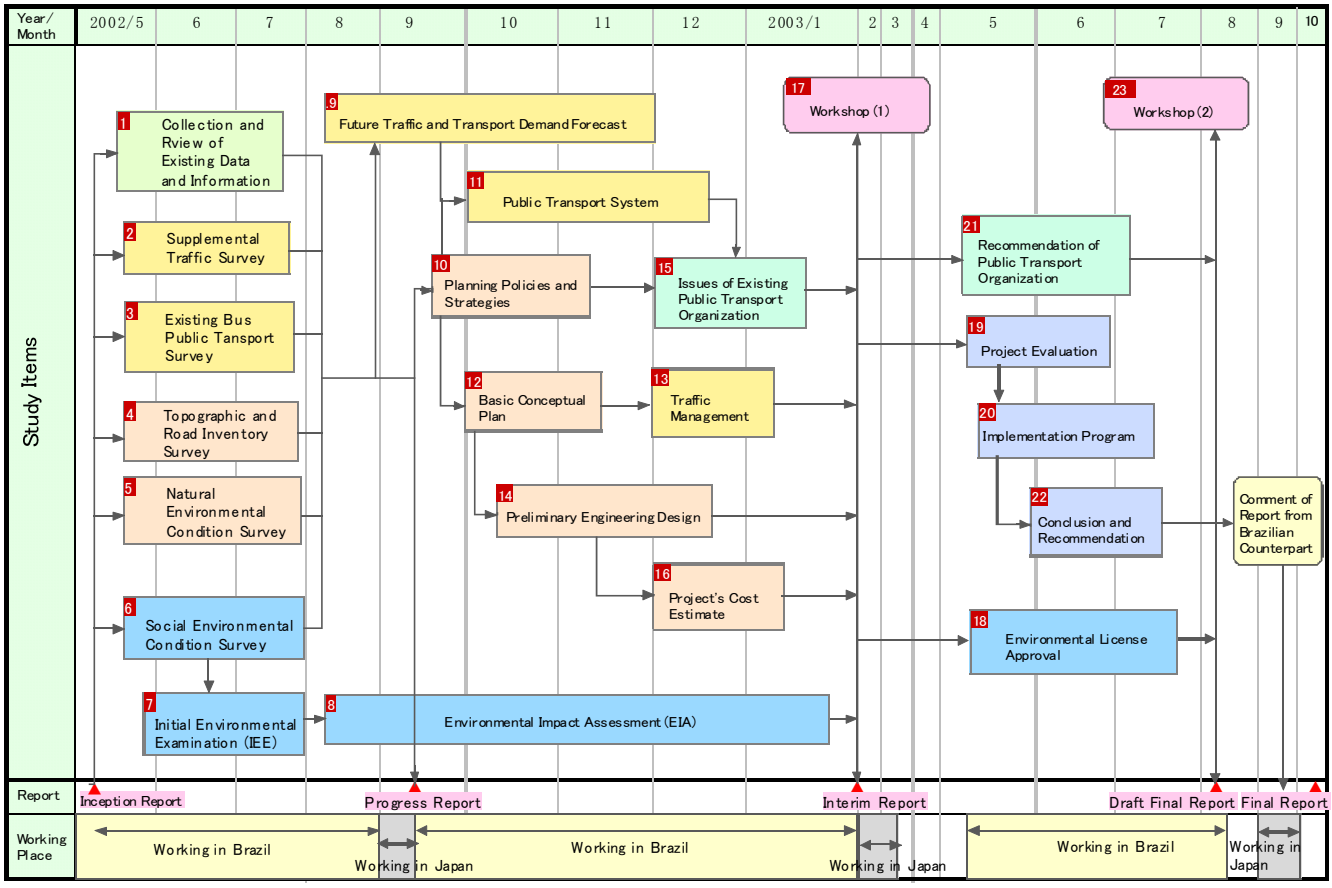


Figure 1-2 Study Flow Chart

1.6. THE STUDY ORGANIZATION

In order to conduct the Study, JICA organized the Study Team headed by Mr. Kenichi Sekine and the Advisory Committee chaired by Dr. Koshi Yamamoto. At the same time, the Government of Brazil organized the Counterpart Team and formed the Steering Committee chaired by Mr. Jose Augusto Soares Affonso, State Special Secretariat of Regional Integration, SEIR, Government of State of Para. The schematic organization chart for the study is shown in Figure 1-3.

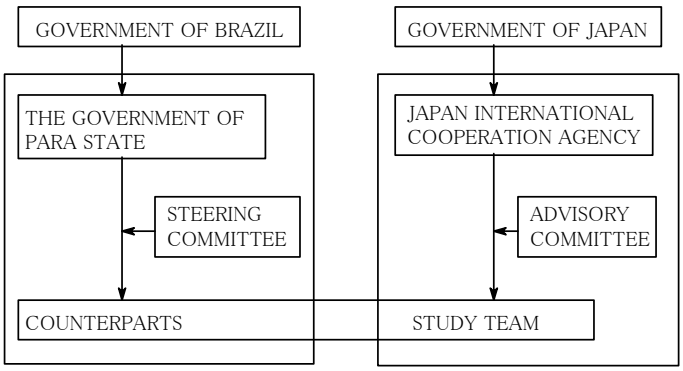


Figure 1-3 Organization Chart

2. PRESENT CONDITIONS IN THE STUDY AREA

2.1. DEMOGRAPHICS

The total populations in 1990 and 2000 in the Belem Metropolitan Area (BMA) were 1.4 million and 1.9 million, respectively. The population growth ratio since 1990 was approximately 1.34, equivalent to 3.0% per annum. The regions with higher growth rates are located in suburban areas. The figures range from 1.9 to 2.7 during the decade. On the other hand, the growth rate in the Central Area in Belem, which is the business and commercial district, is as low as 1.06 to 1.10. This indicates that the area developing as a residential area extends to the suburbs in the direction of Ananindeua.

2.2. EXISTING TRAFFIC AND TRANSPORT CONDITIONS

(1) Traffic and Passenger Volumes

Total daily inbound and outbound traffic volumes on screen line-1 are approximately 74,000 and 75,000 veh/day, exclusive of bicycles, respectively, while on screen line-2, the inbound and outbound traffic volumes are approximately 57,000 and 52,000 veh/day, exclusive of bicycles, respectively. Figure 2-1 shows the traffic volumes on the screen line-1 and line-2.

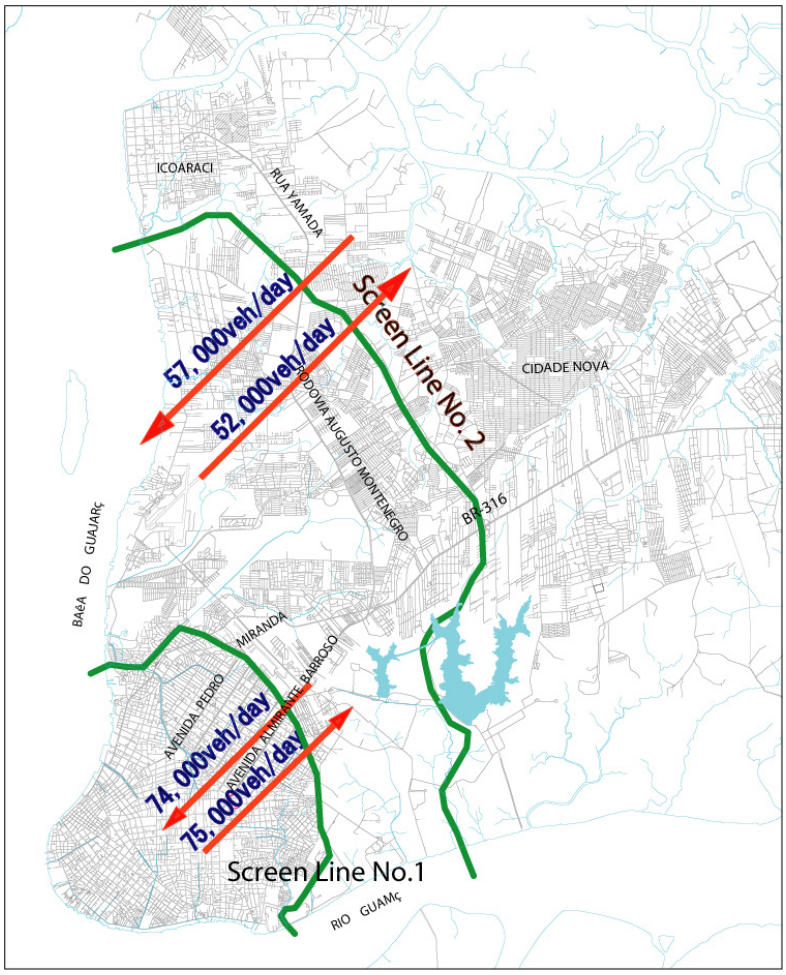


Figure 2-1 Traffic Volumes on Screen Line No.1 and No. 2

As for the daily passengers, approximately 439,000 and 480,000 passengers/day pass through on screen line-1 in the inbound and outbound directions, respectively. On the other

hand, the daily passenger volumes on screen line-2 are approximately 257,000 in each direction, a difference of roughly 181,000 and 223,000 passengers in each direction.

The passenger volume in the inbound direction at peak hour on screen line-1 is approximately 73,000 passengers/hr from 7:00 a.m. to 8:00 a.m., in contrast to 31,000 passengers/hr in the outbound direction. On screen line-2, approximately 29,000 and 14,000 passengers/hr pass through in the inbound and outbound directions, respectively. The hourly fluctuation shows that passenger peak ratios are higher than those of traffic on both screen lines. Those figures in the inbound direction on screen line-1 and line-2 are approximately 17% and 11% of the daily volumes, in contrast to 10% and 7% for traffic volume (see Table 2-1). Those figures indicate 11-17% of daily passengers concentrate in the peak hour.

Table 2-1 Peak Hour Traffic and Transport Indices (Inbound)

Screen Line	Types	Peak hour	Volume	Peak Ratio by 24 hr
1	Vehicles	7:00-8:00	7,614	10.3%
2	Vehicles	7:00-8:00	3,947	7.0%
1	Passengers	7:00-8:00	72,633	16.6%
2	Passengers	7:00-8:00	28,608	11.1%

As for the passengers in the inbound direction on screen line-1, the peak period occurs from 7:00 a.m. to 8:00 a.m. The bus passenger ratio at peak hour reaches approximately 76% of all passengers by transport, in contrast to 66% in the day. The bus transport plays a very important role in the transport modes.

Avenida Almirante Barroso/BR-316 Corridor is the busiest transport corridor including interstate through-traffic. On Av. Almirante Barroso on the screen line-1, the bus traffic volume and passenger volume at the morning peak period in the inbound are approximately 600 veh/hr/direction and 43,000 passengers/hr/direction. It shows that those volumes are close to the limit of road capacity. The share of bus passengers on the road is the highest (86% of the total) in the peak hour. Rodovia Augusto Montenegro Corridor is one of the most important transport corridors in the Municipality of Belem. This road also carries heavy traffic in the peak hour (290 veh/hr/direction and 21,000 passengers/hr/direction). The share of bus passengers on the road is also higher (82%) and the road is also important for public transport.

(2) Trip Characteristics

Table 2-2 shows trips, population and motorized households in the years 1990 and 2002 in the study area. The increase ratio of passenger car trips is approximately 7.5% per annum. On the other hand, bus trips are almost same volume during the decade.

Table 2-2 Trips, Population and Motorized Households in 1990 and 2002 in the Study Area

Item	Unit	1990	2002	2002/1990	
				Ratio	Per annum
Population	Person	1,419,224	1,782,394	1.26	2.3%
Motorized Households	Household	56,044	78,029	1.39	3.4%
All trip Modes	Trips/day	2,888,003	3,765,799	1.30	2.2%
Passenger Cars	Trips/day	366,190	876,514	2.39	7.5%
Buses	Trips/day	1,544,975	1,700,332	1.10	0.8%

Note: Figures in the column of population and motorized households in 2002 are for 2000.

As for the peak hour OD trips, a summary of travel demand is shown in Table 2-3. The total number of person trips exclusive of walking, bicycle and motorcycle modes in the morning peak hour in the study area in 2002 is forecast at 410,000 trips/hour. The peak hour trip ratio is 15.6%. The share of public transport is approximately 73% in the morning peak hour, in contrast to 65% for daily unit. In the peak hour, the ratio of public transport is higher than that of daily trips.

Table 2-3 Travel Demand in Peak Hour in 2002

Types	Peak Period	Day	Peak Ratio
Private	112,668	924,719	12.2%
Public	297,825	1,700,332	17.5%
Total	410,493	2,625,051	15.6%
Private	27.4%	35.2%	
Public	72.6%	64.8%	
Total	100.0%	100.0%	

2.3. TRAFFIC MANAGEMENT ADMINISTRATION

The transport related sections in municipalities are responsible for the administration of traffic management. For the municipalities of Belem and Ananindeua these are CTBel and DEMUTRAN, respectively. A part of the traffic management, such as the part of traffic safety education, is responsibility of all organizations including DETRAN in Para State, CTBel and DEMUTRAN in the Belem and Ananindeua municipality. DETRAN (Traffic Department of Para): is responsible for vehicle register and driver competences, statistics accidents and traffic safety education in Para State.

2.4. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

2.4.1. INTRODUCTION

This IEE summarizes the results of the Initial Environmental Examination (IEE), which assesses the potential impacts associated with the Study presented for the detailed design study to be followed at next stage. In additions, current environmental baseline conditions and legal and administrative framework of Brazil are described. Based on those environmental information, the screening and the scoping of the proposed project are conducted.

2.4.2. DESCRIPTION OF ENVIRONMENT

The variation of the flora/fauna around the study area is in rich conditions. There are two environmental reserves preserved by Para State and Belem Municipality around the study area: i.e., (1) Presidente Medici II, preserved by Belem Municipality, and (2) APA Belem, preserved by Para State. Basically, any construction works, planning, and activities that lead to the environmental deterioration of APA Belem are strictly prohibited. Beside those two parks, some portion of the wetland around the downstream side of Paracuri River, Icoaraci, is currently investigated for the preservation purpose. Recently, water quality degradation due to the direct discharge of the household wastes into the tributaries running through those parks becomes one of big environmental concerns. Also, the amount of the illegal waste dumping inside of those parks is increased due to the improved accessibility into those parks from nearest residential area. In order to protect those areas, several protection measures were taken (e.g., APA Belem Protection Project, Para State).

Most of archaeological/historical/cultural and/or monumental facilities to be conserved exist within the downtown area of Belem City. The damages of historical facilities due to the traffic vibration were reported around Centro region, and an anti-vibration measure was implemented to some of those damaged facilities four years ago.

Neither of periodical air quality, water quality nor noise monitoring study and/or program is conducted in Belem, yet. In PDTU 2001, preliminary roadside noise/vibration survey was carried out at nine points across the metropolitan area of Belem

2.4.3. LEGAL AND ADMINISTRATIVE FRAMEWORK OF EIA

EIA evaluation and relevant public involvement process are described in following four laws,

- Federal Constitution.
- Law of Environmental Impact Assessment (CONAMA Resolution 001 of 1986)
- Law of Public Participation Process in EIA (CONAMA Resolution 009 of 1987)
- Law of EIA and Environmental License Approval (Decree 99.274 of 1990)

In Brazil, environmental standards for air quality, water quality and noise exist. No environmental standard for the vibration exists in Brazil.

2.4.4. ENVIRONMENTAL LICENSE APPROVAL PROCESS IN BRAZIL

The main purpose of EIA study is to obtain the environmental license issued by the Ministry of Environment, the Government of Brazil. Officially, EIA work of the proposed project can start after the term of reference (TOR) of environmental studies required for the EIA evaluation process is fixed. In general, this TOR of the EIA study is to be determined through the consultation with SECTAM.

Followings are the major steps of the EIA evaluation process,

1) Prepare for the project brief of the proposed project that contains the outline of the proposed project and its surrounding environmental information.
2) Determine the TOR of EIA works of the proposed project in consultations with SECTAM. Those consultations should be carried out, based on the submitted project brief.
3) Carry out relevant environmental studies of EIA, mainly based on the TOR determined in previous step.
4) Prepare for EIA/RIMA D/F reports.
5) Prepare for the public participation process, and then, collect public opinions to the proposed project through this process.
6) Incorporate public opinions collected in previous step into EIA/DF, and prepare for the final version of EIA report. Eventually, the examination of the environmental license approval by SECTAM starts. If the contents of the EIA study of the proposed project are satisfactory, then, this license approval process moves to next final step.
7) Final examination will be made by COEMA (Conselho Estadual de Meio Ambiente), and the environmental license will be issued if no objections and/or further controversial discussions arise.

2.4.5. FIELD SURVEY RESULTS

(1) Air Quality Survey

1) PM-10

All measured PM-10 values (maximum measured value = 65.1 μg/m^3) are below the current air quality standard (1-day averaged standard = 150 μg/m^3). Throughout this survey, relatively large PM-10 values are detected along the heavy traffic roads such as BR 316, Nazare, Av. Almirante Barroso (San Braz), Av. Almirante Barroso (Bosque) and Av. Augusto Montenegro. So it can be said there is a strong correlation between the current traffic condition and the spatial variation of PM-10 concentration.

2) CO

All measured CO values are below the current air quality standard (1 hour-averaged standard = 35 ppm). Throughout this survey, relatively large CO values are detected along the heavy traffic roads running through relatively crowded residential area such as points along Av. Nazare, Rua Av. Gama Abreu, Av. Almirante Barroso, Rua Joao Balbi, and Av. Almirante Barroso. Most of measured CO values tend to decrease during the night-time and reach the lowest values around the early morning. Basically, several peaks are found within this survey results (maximum measured peak value = 2.4 ppm), and this fluctuation pattern may be due to the current transport mode around the sampling points (e.g., each concentration peaks seem to correspond the current transport peaks such as morning, noon and evening, respectively). Figure 2-2 shows the daily fluctuation pattern of roadside CO concentration value measured at Sao-Braz.

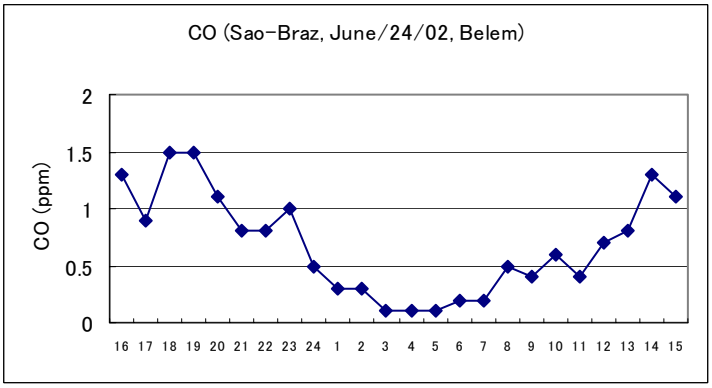


Figure 2-2 Roadside A/Q Survey Results (CO, Sao-Braz, June/24/02)

3) NO2

All measured NO2 values are below the current air quality standard (primary 1 hour-averaged standard = 320 μg/m^3). Throughout this survey, relatively large NO2 values are detected along the heavy traffic roads within relatively crowded residential area such as points along BR 316, Rua Gama Abreu, Av. Almirante Barroso, Rua Joao Balbi, Av. Almirante Barroso and Rov. Augusto Montenegro. Figure 2-3 shows the daily fluctuation pattern of roadside NO2 concentration value measured at Sao-Braz.

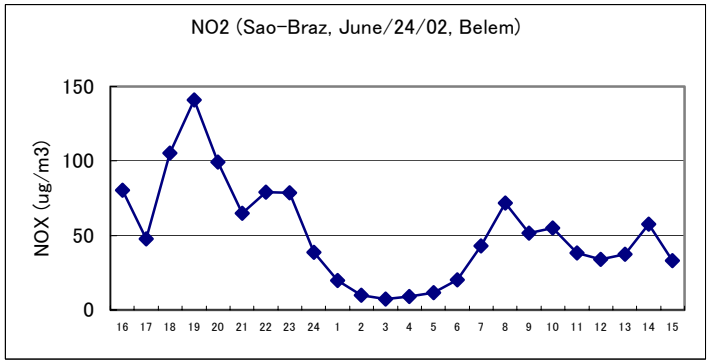


Figure 2-3 Roadside A/Q Survey Results (NO2, Sao-Braz, June/24/02)

4) SO2

All measured SO2 values (maximum measured value = 31.1 μg/m^3) are far below the current air quality standard (1 day-averaged standard = 365 μg/m^3). Since current atmospheric SO2 concentration across the city is quite low and hydro-desulfurized fuel are already marketed, so it was quite rare to detect large SO2 concentration within this study

(2) Noise Survey

Strong daily fluctuation pattern that would correspond to traffic flow pattern is recognized within the survey results of all roadside points. Most of roadside Leq variation patterns seem to have three peaks that would correspond to traffic peaks (i.e., morning, noon and evening), and tend to be subdued around 40 – 60 dBA during the nighttime.

In Brazil, the daytime noise standards (7:00 – 22:00) for the commercial/mixed and residential zones are of 60 and 55 dBA, respectively, and most of Leq measured at all roadside points exceed those standards. So it can be said that current daytime roadside environment is noisy and might cause some disruptions in human health such as hearing changes, losses, interference with speech communication and/or annoyance. By the same token, nocturnal noise standards (22:00 – 7:00) for the commercial/mixed and residential zones are of 55 and 50 dBA, respectively. Similarly, most of nocturnal Leq measured at all roadside points exceed those standards, so it can be said that current nocturnal roadside noise environment is not good, either.

(3) Vibration Survey

Most of roadside VAL variation patterns seem to have three peaks that would correspond to traffic peaks (i.e., morning, noon and evening), and tend to be subdued around 40 dB during the nighttime.

As described earlier, no vibration environmental standard is introduced in Brazil yet. Permissible daytime (6:00 – 22:00) and nighttime (20:00 – 6:00) vibration standard for residential area, implemented in Japan, is of 65 and 60 dB, respectively. Note these Japanese vibration standards are based on L10 concept. Here in Belem, most of daytime VAL values are less than 60 dB, so it can be assumed that L10 values at all points would be less than 54 dB or 52 dB, provided that strong correlation between L10 and VAL, mentioned previously, exists. Thus, it can be said that daytime roadside vibration environment is not so severe.

By the same token, most of nighttime VAL values are varied around 40 dB, so it can be said that nighttime roadside vibration environment is not so significant, either.

(4) Water Quality Survey

Within the water quality survey, it was found that the surface water qualities at all sampling points are not in good condition. Water quality degradation due to the discharge of untreated household effluents were recognized at several sampling points, including points located in the watershed of APA Belem. Compared with the water quality condition of the surface water, pH values of entire samples are somewhat lower than those of surface water, and all BOD, COD and Coli-form values are considerably low. Water quality degradation due to the accidental spillage of untreated household effluents were recognized at several shallow wells.

2.4.6. SCREENING AND SCOPING OF THE PROPOSED PROJECT.

Preliminary environmental examination of each major route component is carried out separately, and potential environmental issues associated with each major road are summarized as follows.

(1) Avenida Almirante Barroso

Several historical/cultural and/or monumental facilities to be conserved exist along this road. No rare flora/fauna is reported along this route.

(2) Rodovia BR-316/Av. Mario Covas/Cidade Nova

Recent urban development of Belem City has started mainly along Rodovia BR-316, one of important commuting road that connects Belem, Annanindeua and Marituba, while Avenida Mario Covas connects Belem CBD and Cidade Nova. No rare flora/fauna is reported along this route.

(3) Avenida Augusto Montenegro

This avenue is also one of important commuting roads, that connects Icoaraci and Belem, one of the major suburban residential area, and Belem CBD. No rare flora/fauna is reported along this route.

(4) Avenida Independencia

Currently, some portion of this project route between Augusto Montenegro and Marituba is under construction while Macro-Drainage Project that is to improve the regional drainage and its associated road improvement project is at the construction stage along some portion of this project route between Augusto Montenegro and Av Pedro Cabral. Some portions of this project route are to pass the circumference of the environmental reserve, Presidente Medici II. Existences of many illegal squatter's communities are reported. Some areas along this project route are flood-prone during the rain season.

(5) Rua Da Marinha

Some portion of this project route is to cross along the boundary line between the current environmental reserve, Presidente Medici II, and its neighboring site of Naval Military Base, that has a strong ecological continuity to the current preserved area. Large-scale land-take is expected to occur within site of the Naval Military Base.

(6) Av. Primeiro De Dezembro

Some portion of this project route is to directly cross the environmental reserve, APA Belem. Currently, the wall construction of APA Belem Protection Project has already started, although entire expropriation negotiation process is not settled down completely.

Existences of many illegal squatter's communities are reported, and most of those residents use groundwater.

(7) Ruas Chermont, Yamada and Tapana

This project route would run directly through three important facilities (one airport and two military facilities). The direct interference, cumulative or secondary impacts of those facilities with this project are expected to occur. No rare flora/fauna is reported along this route. Existences of many illegal squatter's communities are reported.

(8) Av. Pedro Cabral

No rare flora/fauna is reported along this route. Some areas along this road are flood-prone during the rain season.

(9) Av. Senador Lemos

No rare flora/fauna is reported along this route. Some areas along this road are flood-prone during the rain season.

(10) Nazare/Barara/Presidente Valgas/ Gov. J. Malcher and other major routes of Centro Region

Many historical/cultural and/or monumental facilities to be conserved exist along this road network. The damages of historical facilities due to the current roadside vibration were reported around Centro region. No rare flora/fauna is reported along this route.

3. TRUNK BUS SYSTEM PROJECTS

3.1. EXISTING PUBLIC TRANSPORT CHARACTERISTICS

3.1.1. BUS ROUTE CHARACTERISTICS

There are 165 bus routes in the study area, with each route serviced by a fleet of some 1,900 buses. Almost all of the buses in operation are of conventional bus type carrying approximately 100 passengers (seated and standing). Only three are articulated buses. The total operation kilometers of the conventional buses along 165 routes is about 6,200km. In 2000 when PDTU2001 was being undertaken, microbuses were in operation on 27 routes. However, they are now reduced to only five routes because of their higher fare of R$1.5 compared with R$0.85 of conventional buses among other motives (as of June 2002).

The bus operation requires permits from the municipal transport bureaus of Belem, Ananindeua, Marituba and other cities or towns in which it offers service. Currently, a total of 29 private companies are authorized to service 165 or so bus routes in the study area. The fleet size of these companies varies from about 50 vehicles to over 300. Small companies service about five routes, whereas large companies cover 15 to 20 routes.

The numbers of bus routs in Belem centro area are about 30 bus routes, and 40 bus routes are operating in the area from Belem centro area to Icoaraci area. And the direction between centro area to Cidade Nova and centro area to Marituba also operating about 40 bus routes respectively.

The average bus route length within Belem centro area are about 10km to 15km, however, bus routes from centro to Icoaraci or Marituba are about 20km to 25km respectively.

The existing arterial road network in the study area connects Centro to each outlying agglomeration by one arterial road. By the nature of passenger demand and the structure of network, almost all bus routes connecting the outlying agglomerations to Centro have to concentrate on the same set of arterial roads as shown in Table 3-1 which summarizes the number of bus routes and passengers per major arterial road segment.

Table 3-1 No. of Bus Routes and Passengers by Major Arterial Road Segment

Name of Road & Segment	No. of Traffic Lane(No.)	No. of Bus Route (No.)	No of Passenger (Passenger/ Day)	No. of Bus (Vehicle/Day)
① Rodovia BR-316	4	29	88,027	3,606
② Rodovia BR-316	6	43	208,971	7,160
③ Rod. Mario Covas	4	17	98,222	2,831
④ Rod. Mario Covas	4	7	15,536	1,142
⑤ Rod. Augusto Montenegro	6	30	128,910	4,968
⑥ Rod. Augusto Montenegro	6	37	198,941	6,170
⑦ Av. Almirante Barroso	8	66	343,472	12,317
⑧ Av. Almirante Barroso	8	63	283,969	11,092
⑨ Av. P.A. Cabral	6	25	71,270	3,731
⑩ Av. P.A. Cabral	4	25	66,763	3,703
⑪ Av. Senador Lemos	2	4	25,862	1,518
⑫ Av. Pedro Miranda	6	6	35,421	1,662
⑬ Rod. Arthur Bernardes	2	10	27,794	844
⑭ Boulevard Castilhos Franca	6	23	49,503	2,670
⑮ Av. Marechal Hermes	2*	50	89,157	5,974
⑯ Av. Gov. Jose Malcher	3*	44	118,749	5,154
⑰ Av. Nazare	3*	33	65,189	3,657
⑱ Av. Jose Bonifacio	2	8	34,210	1,439
⑲ Av. Perimetral	2	8	26,514	1,500
⑳ Av. Julio Cesar	4	4	15,831	781

3.1.2. BUS PASSENGER CHARACTERISTICS

Figure 3-1 shows the estimated peak-hour passenger volume on three bus routes proposed for the Trunk Bus System. The bus passenger volume on Rodovia August Montenegro, Rodovia BR-316, and Avenida Almirante Barroso is calculated as 12,000 to 20,000 passengers/hour/inbound-directions, 12,000 to 22,000 passengers/hour, and 33,000 to 44,000 passengers/hour, respectively.

On the other hand, the highest peak hour bus traffic volume of the Rodovia August Montenegro, Rodovia BR-316, and Avenida Almirante Barroso is calculated as 248 bus/ hour/inbound, 327 bus/hour/inbound, and 562 bus/hour/inbound respectively.

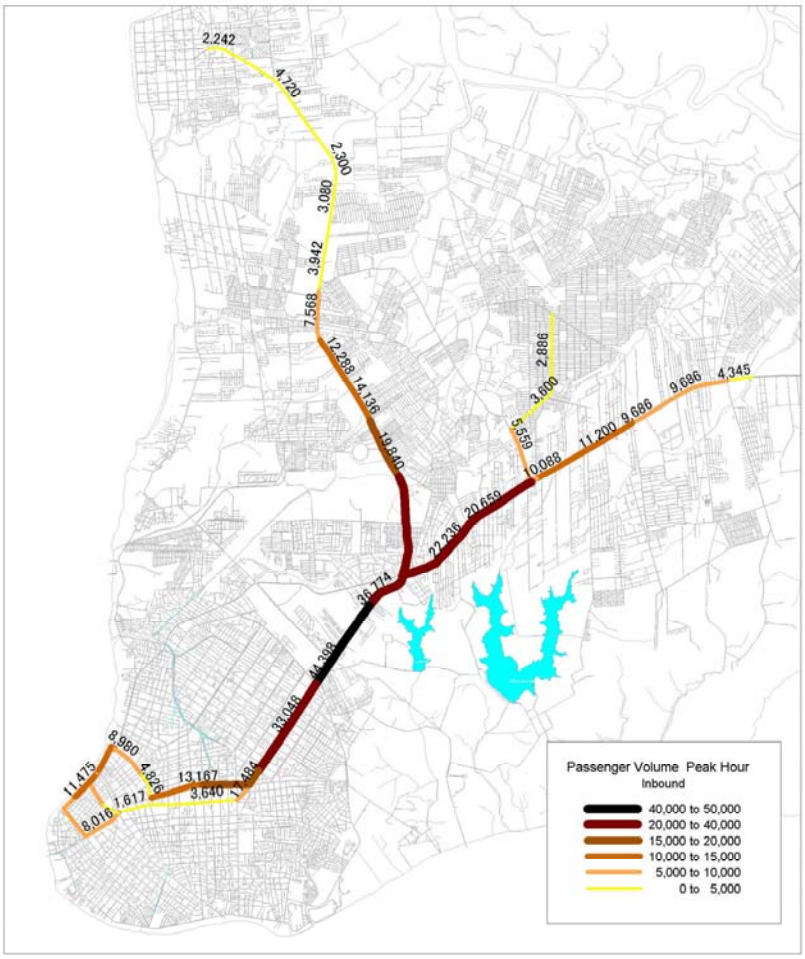


Figure 3-1 Peak-hour Bus Passenger Volume on Major Roads

Figure 3-2 shows passenger boarding and alighting behaviors on the Icoaraci to Centro route during the peak hour. Passengers on board in the vicinity of an Icoaraci terminal is around 20 but jump to 80 – 90 by the time the bus reaches the outer periphery of the built-up area of Icoaraci. At around 7km from the originating terminal, passengers reach the full capacity of about 100 (both seated and standing-up). The full capacity continues through Sao Braz Bus Terminal, where the bulk of passengers get off, leaving 20 or so on board. The bus rarely picks up passengers within Centro.

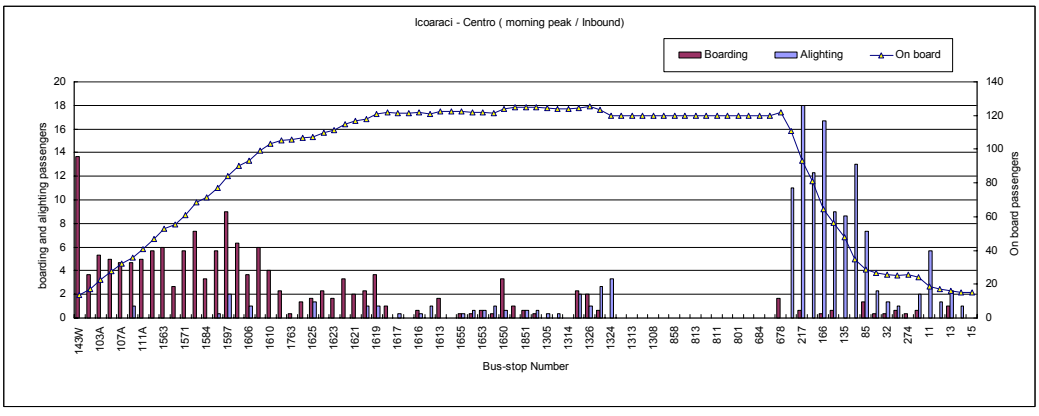


Figure 3-2 Boarding and Alighting Characteristics on Icoaraci-Centro Route

3.1.3. BUS OPERATION CHARACTERISTICS

(1) Bus Operation Speed

The operation speed was more or less stable in the Expansion Area, but slowed down in the Central Area of Belem City. Regarding the Icoaraci – Centro route along Rodovia Augusto Montenegro, the speed was about 25km/h on the four-lane road segment and ranged from 30 to 40km/h on the six-lane segment. On Avenida Almirante Barroso, the operation speed slowly but steadily dropped as the bus approached Centro, and on Avenida Jose Malcher it sometimes dropped to less than 10km/h. The drop of speed was sharp on Avenida. Marechal Hermes where many bus lines converged.

(2) Passenger Travel Time

According to the bus passenger travel time survey at Expansion area, some 73% of the interviewed passengers answered that they reached their destinations in 30 minutes or more. Moreover, the percentage of passengers who traveled one hour or more on the bus to reach their destinations was 21%.

(3) Passenger Boarding and Alighting Time

At bus stops with one passenger waiting, it took the bus 12 seconds for boarding, while it took about 10 seconds for alighting at bus stops where one passenger alighted. The larger the number of boarding and alighting passengers, the longer the bus has to park at bus stops. At bus stops with eight or more passengers waiting to board, the bus took 30 seconds or more to load them. The alighting time was generally 15 to 20% shorter than the boarding time.

(4) Bus Transfer Time

About 75% of the interviewees in the Central Area reached their destinations without transfer. The percentage drops by ten points to 65% in the Expansion Area. 129 bus lines, or 78% of the total bus lines available in the study area, converge in the Central Area. Given this wide range of bus services, passengers find it easier to select a bus line that will take them directly to their destination without transfer.

3.1.4. BUS FACILITY CONDITIONS

(1) Busways

The proposed Trunk Bus System covers such arterial roads as Av. Almirante Barroso, Rodovia BR-316, Rodovia Augusto Montenegro and Av. Independencia. Av. Almirante is a major arterial road, into which Rodovia BR-316 and Rodovia Augusto Montenegro merge. This avenue has the standard cross-section structure comprising the median of 2 to 4m in width, the four-lane two-way through roadway of 7m in width one way. At present, conventional buses share the frontage road with general vehicles, and long distance buses.

Rodovia BR-316 is the main arterial road connecting Marituba City and Belem. The road has the standard cross-section structure comprising the median of 3 to 10m, the six-lane two-way road (one-way width of 11m) and the sidewalk of 3 to 7m on both sides.

Rodovia Augusto Montenegro is the main arterial road that connects Icoaraci and Belem Centro. This road comprises the median of 3 to 5m, the bicycle lane of 1.5m, the six-lane two-way road (one-way width of 11m) and the sidewalk of 3 to 5m.

On Rodovia BR-316 and Rodovia Augusto Montenegro, buses share the outer lane with private vehicles. It will be relatively easy to provide a two-lane two-way exclusive busway (tentative) on the available road space.

(2) Bus Terminals

There are 47 bus terminals that function as points of origin and destination. These terminals service several bus routes each. There are three integrated bus terminals where passengers can transfer from one bus route to another without paying additional fare. There is one terminal for long distance buses to or from Brasilia, Sao Paulo and elsewhere.

(3) Bus Stops

The number of bus stops, counting both ways, totals 2,480 or thereabouts. Between Icoaraci and Belem Centro, there are about 160 bus stops with average spacing of 340m. Some 115 bus stops exist between Cidade Nova and Centro with average spacing of 330m. There are about 120 bus stops between Marituba and Centro with average spacing of 380m. Bus stop facilities commonly consist of roofed waiting space and a few benches. There is no information board showing a service schedule or route map.

3.1.5. BUS FLEET CONDITIONS

The total fleet in operation consists of about 1,900 conventional buses and a few articulated buses. In addition, a small fleet of microbuses are in operation on 5 routes. Photo 3-1 shows a typical conventional bus.

3.1.6. BUS TARIFFS

Passengers normally have to pay the tariff at every occasion of transfer from one bus route to another. However, the integrated system is in operation at three bus terminals where passengers can transfer without paying the tariff. This integrated system of transfer applies only to the fleet of one bus company which also runs the terminal or of two companies which jointly run the terminal.

After boarding a bus through the rear door, each passenger goes through the turnstile and pays the tariff to the conductor, either in cash or by a ticket bought before boarding. Coupon tickets, monthly passes and ticketing cards of prepaid type are not in use. Passengers alight through the front door of the bus. Those passengers who are exempt from paying the tariff board the bus through the front door.

The Transport Company of each municipal government controls the fare rates. CTBel of Belem City, for example, sets the rates as shown below. Neighboring cities of Ananindeua and Marituba adopt the same rates.

1) Buses without airconditioning: R$1.00 (as of November, 2002)
2) Airconditioned buses: R$1.70 (as of November, 2002)

Photo 3-1 Conventional Bus

3.1.7. BUS COMPANIES

There are a total of 29 private bus companies in the study area, and about eleven of them service bus routes within Belem Centro. About five companies carry passengers mainly on Icoaraci-Centro routes. About seven companies service chiefly Cidade Nova-Centro routes and Marituba-Centro routes, respectively.

The fleet of buses in operation in the study area totals 1,900 vehicles. Six companies operate a fleet of 100 buses or more, accounting for 53% (990 vehicles) of the total buses in operation. Eight companies run a fleet of 50 to 99 buses, and twelve companies have a fleet of less than 50. There are a total of 165 bus routes in the study area. Six larger companies mentioned above service 89 routes, or 57% of the total.

3.2. FUTURE TRANSPORT DEMAND FORECAST

3.2.1. SOCIO-ECONOMIC FRAMEWORK

Table 3-2 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 Belem Metropolitan Area.

Table 3-2 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

3.2.2. TRAVEL DEMAND FORECAST

(1) Number of Trips

Table 3-3 shows the estimated car/other and bus trips in the future. The total number of person trips in 2012 in the Study area is approximately 3,876000 trips/day, of which 1,788,000 trips are Car/others' passengers, and 2,088,000 trips are for bus. The bus passenger share to the all modes is approximately 54%.

(2) Trip Distribution

Figure 3-3 illustrates the desire lines in the morning peak hour by the bus modes for inter-zonal trips in 2002 and 2012. As seen in 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.

Table 3-3 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

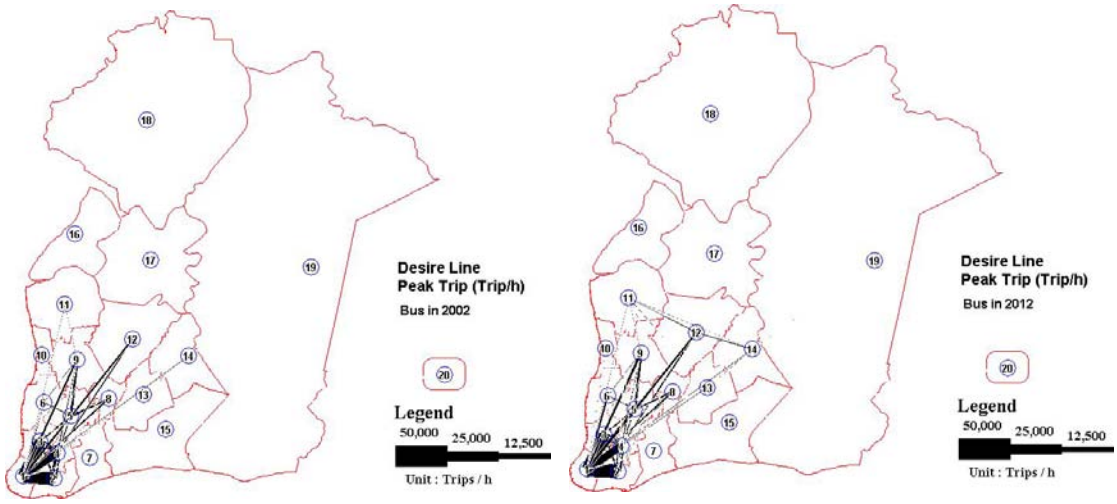


Figure 3-3 Peak Hour Trip Desire Lines by Bus Mode in 2012

(3) Future Traffic Volume on Major Roads

In the present traffic conditions shown in the left side in Figure 3-4, 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.

In 2012 (right side in Figure 3-4), 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. Independencia and Av. Primeiro de Dezembro are made in the transport network.

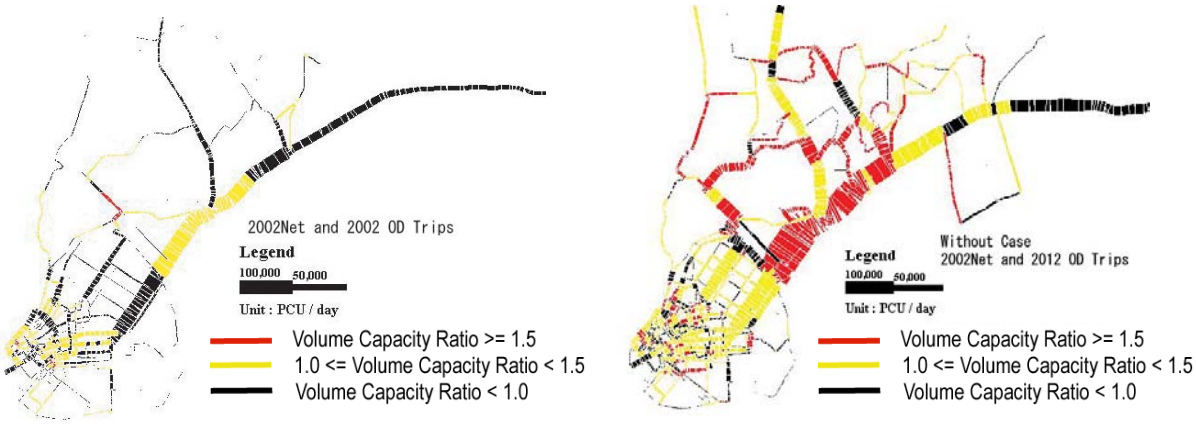


Figure 3-4 Traffic Volume in 2002 and 2012 on the 2002 Road Network

3.3. CONCEPTUAL PLANNING FOR TRUNK BUS SYSTEM

3.3.1. BASIC PLANNING POLICY AND STRATEGY

The introduction of a trunk bus system offers a solution to the current problem of bus transportation. The new system will ensure functionally efficient bus operation and thereby help ensure the sound functioning of Belem City. As shown in Figure 3-5, the basic planning policy for the proposed trunk bus system takes into full account the expected benefits and advantages to (i) bus passengers, (ii) bus companies, (iii) urban citizens in general, and (iv) the urban environment.

The strategy to pursue the basic planning policy comprises the following actions.

1) To identify the problems and issues of the existing bus transport system;
2) To analyze the factors that lie at the root of these problems and issues;
3) To plan various projects to solve the problems and to cope with the issues; and
4) To examine and propose the institutional, or software, measures (e.g., bus operation and management) and the physical, or hardware, requirements (e.g., roads for bus transport) that are considered necessary to establish a sound urban transport system.

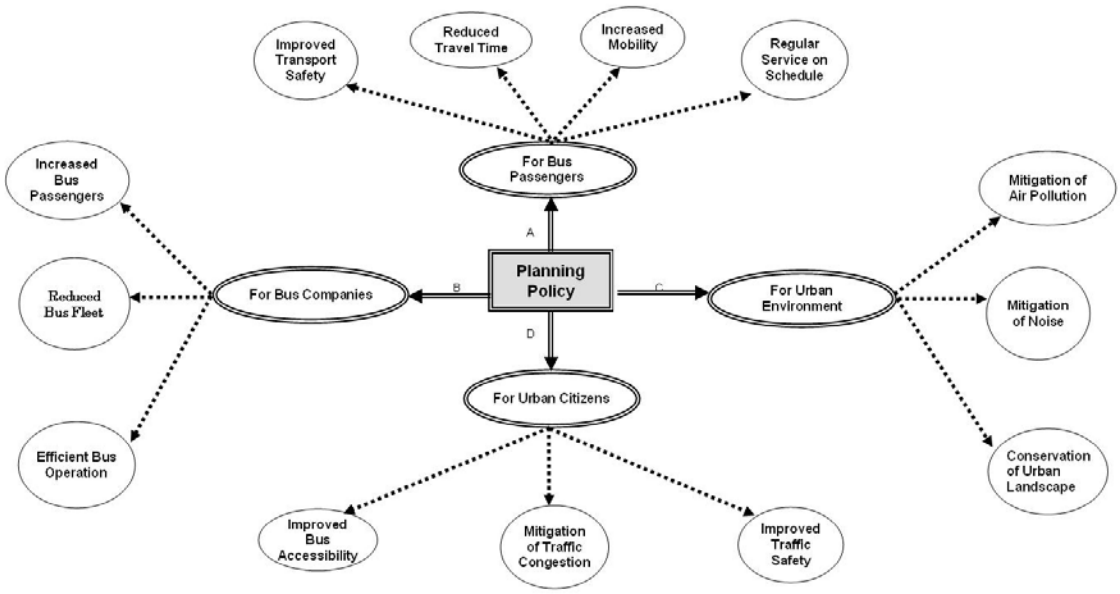


Figure 3-5 Basic Planning Policy

The institutional measures directly concern the existing bus companies. Therefore, the planning closely examines the details of the existing practices to offer feasible proposals on bus operation and management that will be acceptable to these companies. Given the urgency of improving the existing bus transport, the physical planning assumes that the proposals on construction and improvement conform to the rights of way of the existing roads without involving any new land acquisition.

3.3.2. CONCEPTUAL PLANNING FOR TRUNK BUS SYSTEM

(1) Bus System in the Study Area

The Study proposes a new bus transportation plan that combines (i) a trunk bus system, (ii) a conventional bus system and (iii) a feeder bus system. The proposed trunk bus system is divided into three components depending on the type of lane, or of road structure, it utilizes: i.e., trunk busway, exclusive trunk bus lane and trunk bus priority lane. The proposed plan calls for the introduction of larger buses in order to reduce the number of bus fleet in operation and thereby to alleviate the traffic congestion. Specifically, the new bus is the two-bus articulated type of 200-passenger capacity that is already in use in Sao Paulo, Curitiba and elsewhere.

The trunk busway is introduced to the following existing roads: namely, (i) those route segments where bus passenger demands are very high (10,000 or more passengers per hour), (ii) the existing arterial roads that have the rights of way wide enough to construct the two-way trunk busway (about 10m in width) without additional land acquisition, and (iii) the two-way arterial roads that have six or more lanes. The trunk busway is segregated by some concrete structure from the through traffic lane in order to ensure the regular trunk bus service according to schedule and the traffic safety.

The exclusive trunk bus lane is introduced to the following existing roads: namely, (i) those route segments where bus passenger demands are fairly high (from 8,000 to less than 10,000 passengers per hour), (ii) the existing or planned arterial roads that have the rights of way wide enough to construct two trunk bus lanes (about 7m in aggregated width) without additional land acquisition, and (iii) the two-way arterial roads that have six or more lanes. The exclusive trunk bus lane is introduced on both sides of the median on the two-way roads with six or more lanes. The lane is segregated by some lane marking like delineators from the through traffic lane.

The trunk bus priority lane is introduced to the following roads: namely, (i) those route segments where bus passenger demands are fairly high (from 8,000 to less than 10,000 passengers per hour), (ii) the two-way arterial roads that have four or more lanes, (iii) those roads on which the traffic load is large enough to reduce the bus operating speed, and (iv) those roads with no possibility of widening. The trunk bus priority lane is introduced next to the right-side sidewalk. The lane is not segregated by any structure, but paved in distinct color to attract attention.

The conventional bus system operates the bus lines other than the trunk bus and the feeder bus lines. The present operation system, including bus lines, service frequency, bus companies and so forth, is retained without any change. The fleet consists of conventional buses with 100-passenger capacity.

The feeder bus system operates in an area around a trunk bus terminal to carry passengers to and from the terminal. Its service area is limited to a relatively small area in the suburbs, with relatively short route length and smaller number of passengers per bus. Because feeder buses probably run on narrower roads, the fleet consists of smaller buses with 70-passenger capacity.

(2) Roads Selected for Trunk Bus System

The three roads are selected for the introduction of the trunk busway, which are 1) Avenida Almirante Barroso, 2) Rodovia BR-316, and 3) Rodovia Augusto Montenegro. The exclusive trunk bus lane is introduced to Av. Independencia. The following six roads are selected for the introduction of the trunk bus priority lane.

1) Avenida Governador Jose Malcher

2) Avenida Magalhaes Barata/Nazare

3) The road link to connect Av. Governador Jose Malcher (one-way road) to Av. Magalhaes Barata/Nazare (one-way road)

4) Avenida Mario Covas

5) Travessa Cristovao Colombo

6) Travessa Sao Roque

Figure 3-6 shows the location of the trunk busway, the exclusive trunk bus lane and the trunk bus priority lane.

(3) Bus Capacity

The proposed trunk bus system aims at increasing the average passenger per bus of larger capacity to reduce the fleet in operation, to alleviate traffic congestion and ultimately to create an efficient bus operating system. The proposed system for the BMA introduces the type of articulated buses operating in Curitiba City. The transport capacity per articulated bus (vehicle length of 18.0m) is 200 persons including standing passengers. Major specifications are as follows.

1) Articulation of two bodies

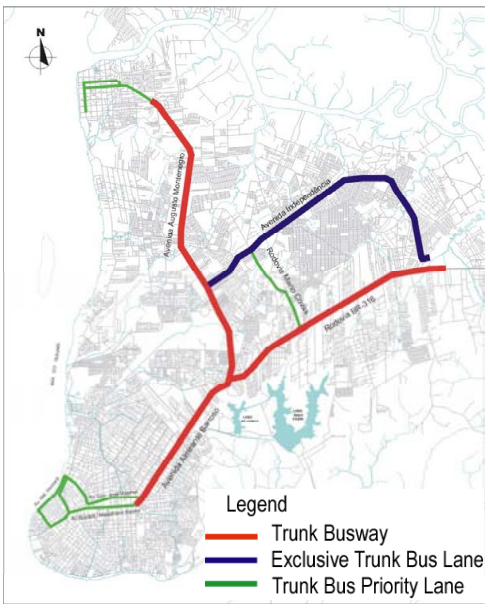
2) Standard capacity of about 200 passengers

3) Because the peak-hour passengers are expected to increase to 120%, or 240 passengers, of the capacity, the body structure must be strong enough to carry the heavy load.

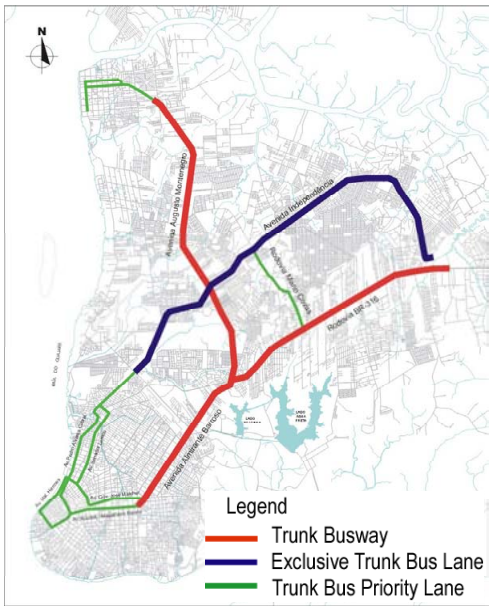
4) Four doors, or two per body, are available for passenger boarding and alighting.

5) Passengers board the bus by the front door and alight from the back door of each body.

6) The doors are provided on the right side of the bodies.



Trunk Bus Network in 2007



Trunk Bus Network in 2012

Figure 3-6 Network of Trunk Busway, Exclusive Trunk Bus Lane and Trunk Bus Priority Lane in 2007 and 2012

(4) Trunk Line Capacity

Table 3-4 shows the trunk line capacity per hour by different service frequency (headway). When articulated buses are operated every 30 seconds, the hourly transport capacity per line comes to 24,000 passengers. When the headway is 20 seconds, the hourly capacity theoretically rises to 36,000 passengers, but this is extremely difficult to put into practice, given, *inter alia*, the time needed for passenger boarding and alighting and the number of available berths at every bus stop. In the event that the passenger demand on the trunk busway should become large enough to require the headway shorter than 30 seconds, it would be more appropriate to introduce the articulated bus linking three vehicles (capacity of 270 passengers).

Table 3-4 Service Frequency and Transport Capacity of Trunk Bus Line

Service Frequency (Headway)	Operatable Buses (units/hour) (A)	Capacity per Articulated Bus (B)	Transport Capacity per Hour (persons/direction/line) (A x B)	Remarks
20 seconds	180	200	36,000	Difficult in operation
30 seconds	120	200	24,000	
45 seconds	80	200	16,000	
60 seconds	60	200	12,000	
90 seconds	40	200	8,000	
120 seconds	30	200	6,000	

(5) Planning Policy for Bus Re-routing

The bus lines assigned to the trunk busway will be in the range of 60 to 70 lines from among 165 conventional bus routes. The remaining bus lines of about 95 belong to the conventional bus system without changing their operating conditions (e.g., routing, bus fleet, service frequency, bus stops, etc.).

Given the present network of bus routes, the expected completion of some arterial road segments under construction or improvement and the future implementation of the planned road construction and improvement projects, the network of the trunk bus system can be mapped respectively for the target years of 2007 and 2012, as shown in Figure 3-6.

(6) Basic Plan of Trunk Bus Operation

The policy for operation planning assumes the following conditions.

1) The bus lines that are not assigned to the trunk bus system belong to the conventional bus system and will keep the existing operating conditions (i.e., operating routes, service frequency, bus companies, etc.)

2) The conventional buses will not use the trunk busway provided next to the median but runs on one of the roadway lanes for through traffic as they have been doing under their present operating systems.

3) The bus lines in the trunk bus system that connect either Icoaraci, Cidade Nova or Marituba to the Centro will divide their respective routes to the trunk and the feeder services. A feeder bus line picks up passengers to transport them to the nearby trunk bus terminal, where passengers can transfer to a trunk bus line.

(7) Trunk Bus Terminal Plan

The proposed trunk bus system operates the trunk and feeder buses. Those buses connect to the integrated bus terminals to transfer those buses. The integrated bus terminal is constructed at the end of trunk bus routes. Taking into account the configuration of trunk

bus routes, eight (8) trunk bus terminals are proposed in the Study, though the four (4) bus terminals was initially proposed as a study project mentioned in Study Area.

The present study proposes to establish eight trunk bus terminals. As shown in Figure 3-7, three terminals (A, B and C) are along Rodovia Augusto Montenegro, two (E and F) along Rodovia BR-316, one (D) on Avenida Mario Covas and two (G and H) along Avenida Independencia, now under construction.

(8) Planning Policy for Bus Stops

To accommodate for transferring passengers between the trunk bus and the conventional bus services, trunk bus stops are located immediately before major intersections where conventional bus lines are operating. In other segments of the trunk busway, bus stops are provided roughly at the ratio of one per two conventional bus stops. The spacing of conventional bus stops ranges from 350m to 400m. Therefore, trunk bus stops are spaced from 700m to 800m.

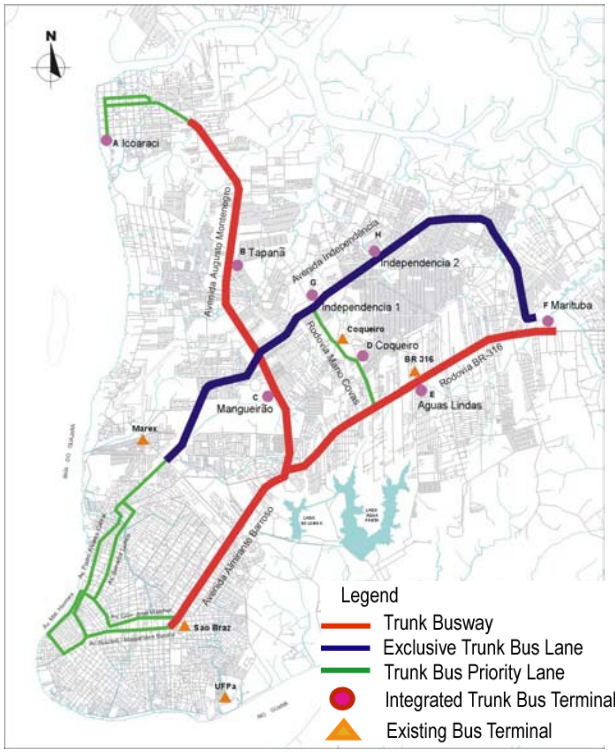


Figure 3-7 Existing Terminals and Proposed Trunk Bus Terminals

(9) Operating Organization for Trunk Bus System

As shown in Figure 3-8, the trunk bus system is divided into two zones for separate operation. Because there is no planned integration between Bus Zones A and B, two separate managing bodies will be established to run the system. Each managing body is organized from the bus companies that currently operate bus lines in the zone. Bus tariffs are collected by the managing body and then distributed to the member bus companies. This type of operating system is already put into practice in Porto Alegre City and elsewhere in Brazil. The basic components of management are as follows.

1) The Zone-A managing body is organized by a number of bus companies (members) that operate the trunk bus service in the zone.

2) The Zone-B managing body is organized by a number of bus companies (members) that operate the trunk bus service in the zone.

3) Bus passengers pay their tariff (i) at the time of boarding a feeder bus, (ii) at the time of boarding at a trunk bus stop, (iii) at a trunk bus terminal, (iv) at kiosks or (v) other designated ticket counters.

4) Collected tariffs are pooled by the zone managing body.

5) The zone managing body distributes the revenue to the member companies.

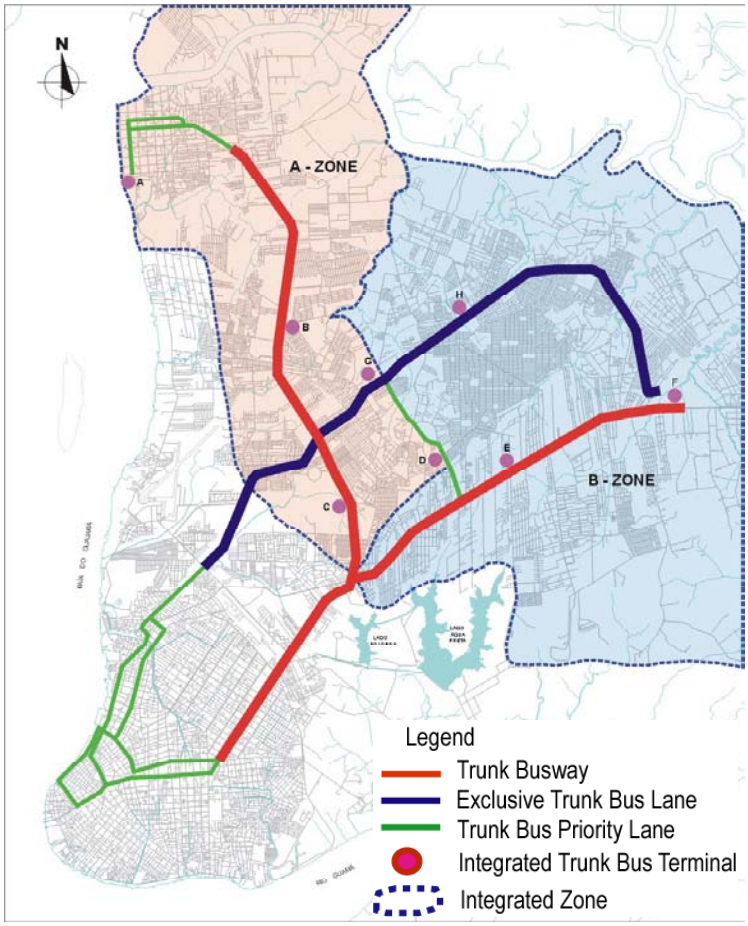


Figure 3-8 Bus Zones A and B of Trunk Bus System

(10) Typical Cross Section of Trunk Bus Routes

There are two alternatives for the busway location: (i) next to the median and (ii) on the right-side lane of the roadway next to the sidewalk. The present Study proposes the first alternative. The exclusive lane is provided on the median-side of roadway. The trunk bus priority lane uses the right-side lane next to the sidewalk.

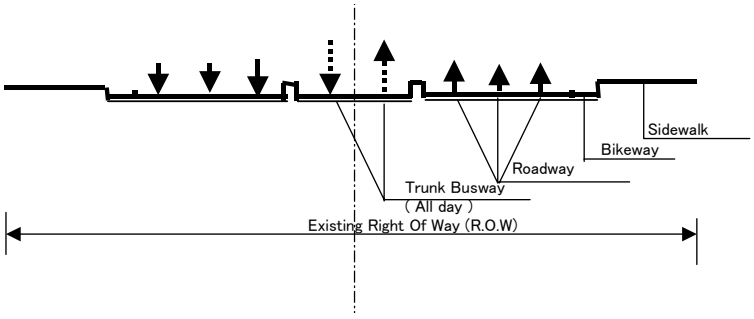


Figure 3-9 Typical Cross Section Location of Trunk Busway