3.4. TECHNICAL ANALYSIS FOR TRUNK BUS SYSTEM

3.4.1. DEMAND FOR TRUNK BUS SERVICE

(1) Trunk Bus Routes

In 2007, there will be two trunk bus routing systems, each comprising a number of trunk bus routes operated from the respective terminals of origin. The routing systems will increase to four in 2012. Two routing systems will use Avenida Almirante Barroso-BR-316 and Rodovia Augusto Montenegro in 2007, and to these will be added two more systems using the central accessing segment of Avenida Independencia between Centro area and Rodovia Augusto Montenegro in 2012. Avenida Independencia, now under construction, will provide two route segments accessing the Centro for two additional routing systems in 2012.

Figure 3-10 shows the two bus routing systems from Terminal A and B in Icoaraci. In this figures, for example, two bus routes TA01 and TA03 both start from Terminal A, but belong to two different routing systems (numbered 01 and 03). TA01 services inside the Centro, but TA03 stops at Sao Braz Terminal to return to its terminal of origin. The routing system from Terminal B (TB01 and TB03) also serves the same as that from Terminal A.

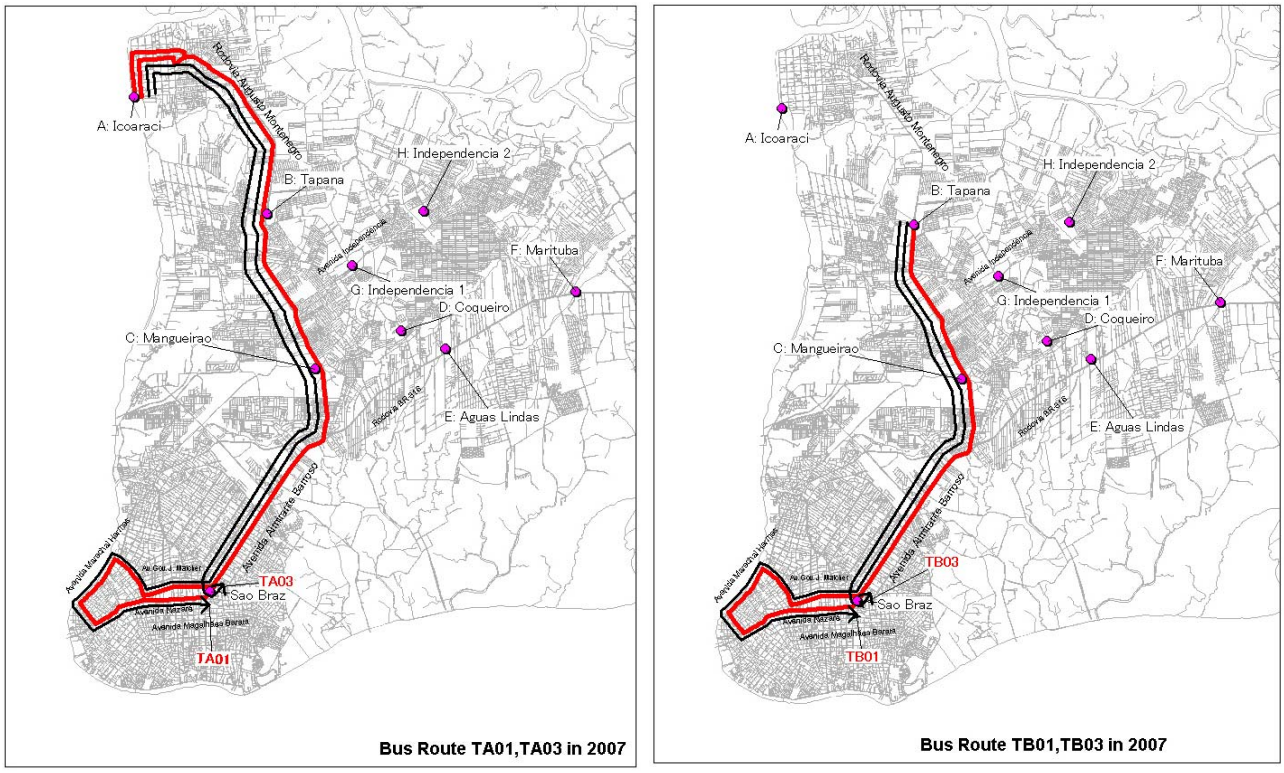


Figure 3-10 Trunk Bus Routing System

(2) Bus Passenger Flows

Figure 3-11 through Figure 3-12 show the forecasts of bus passengers by road segment in 2007 and 2012 in the "with" project case, respectively. The numbers in these figures indicate the inbound passengers on board per morning peak hour. In the "with" demand forecast for 2007 that assumes the introduction of 16 trunk bus routes, the inbound trunk bus passengers from Icoaraci to Entroncamento on Rodovia Augusto Montenegro increase from some 2,000 on the first segment to 16,000 on the last segment, and then jump to 25,000 on the first segment of Avenida Almirante Barroso after joining the inbound

passenger flow on Rodovia BR-316. The inbound trunk bus passengers from Marituba to Entroncamento on BR-316 increase from 6,000 on the first to 14,000 on the last segment. The estimated conventional bus passengers on Avenida Almirante Barroso segments will be reduced to less than 50% of the estimates in "without" case. The conventional bus passengers on Avenida Almirante Barroso in "without" case that reach some 45,000 in one segment are split, in "with" case, into the trunk bus service on Avenida Almirante Barroso.

The "with" case in 2012 assumes the operation of 32 trunk bus. The trunk bus passenger flows are 22,000 on Avenida Almirante Barroso. The inbound passengers on Avenida Independencia reach 14,000 to 16,000 in the higher volume segments.

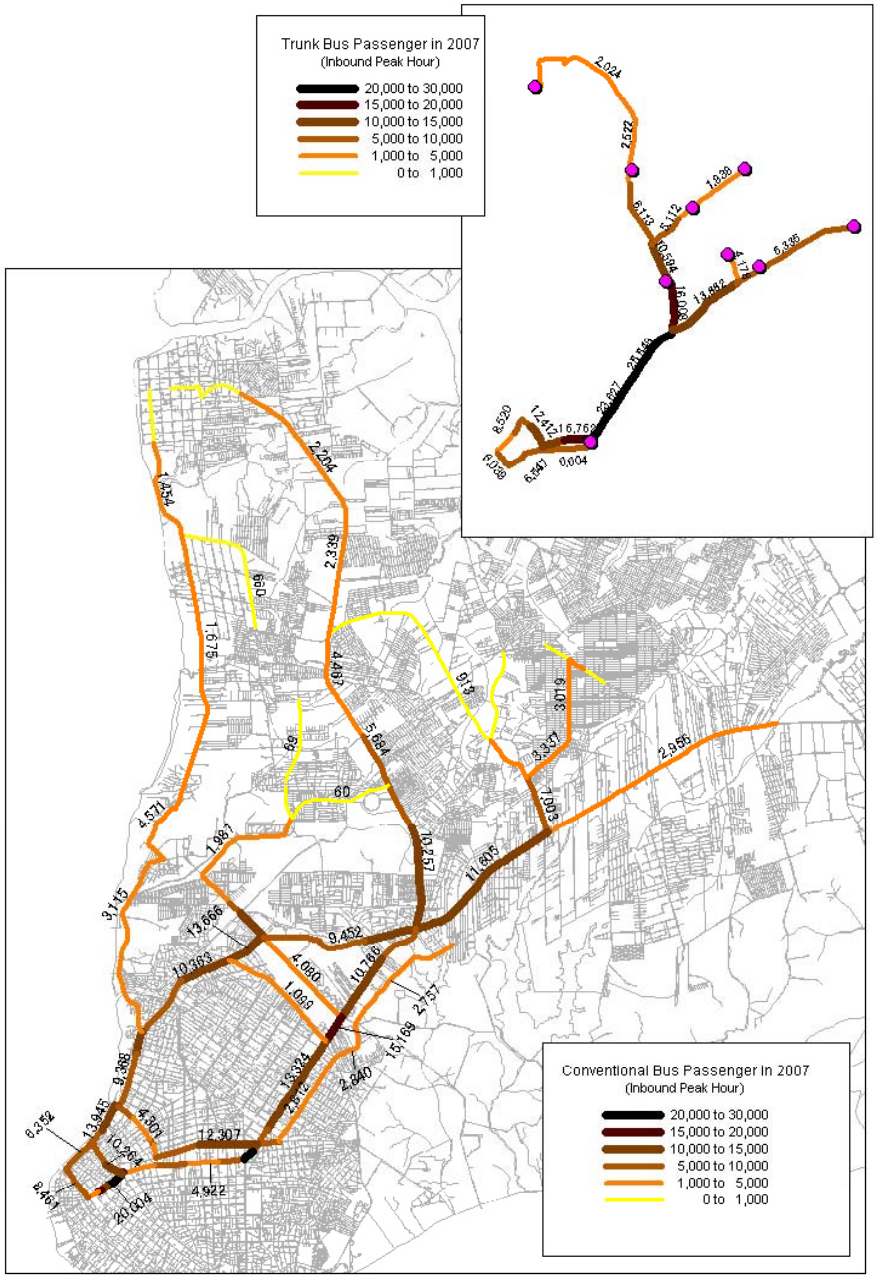


Figure 3-11 Peak-hour Bus Passenger Flows in 2007 with Trunk Bus System

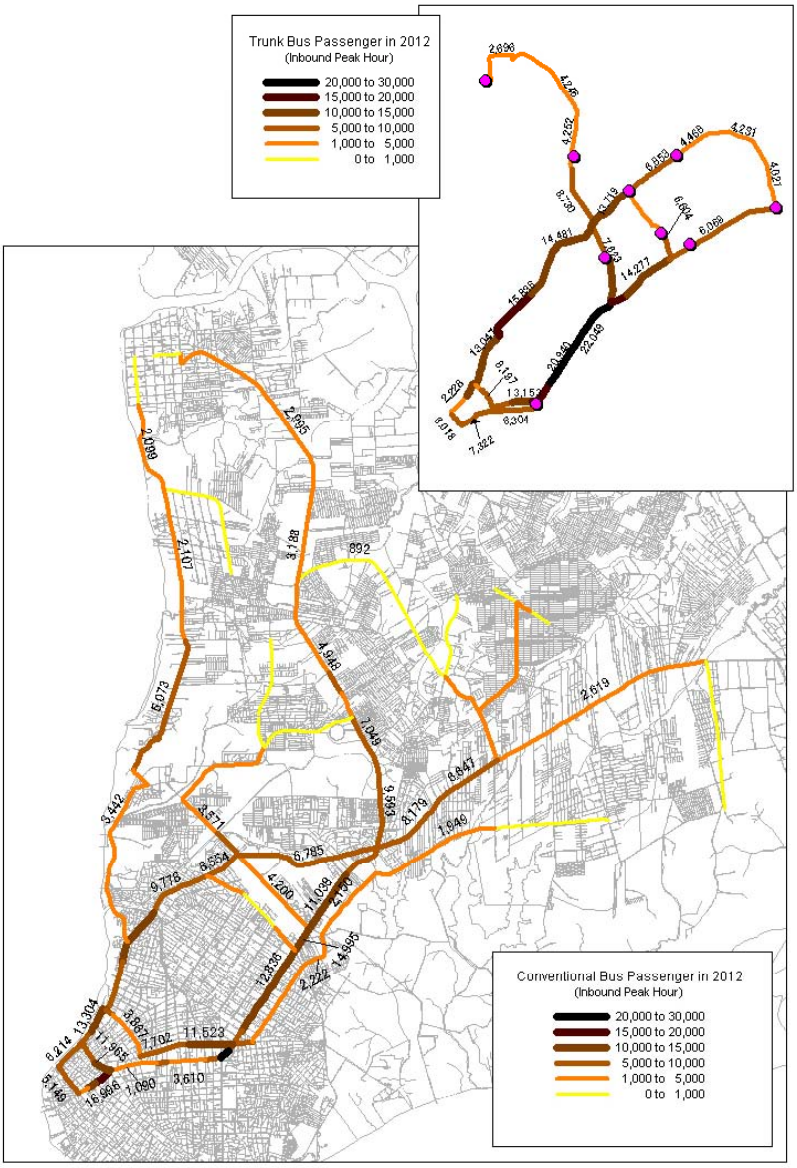


Figure 3-12 Peak-hour Bus Passenger Flows in 2012 with Trunk Bus System

(3) Bus Service Frequency

Figure 3-13 shows the conventional and trunk bus traffic in 2012. The trunk bus traffic on Av. Almirante Barroso is 128 vehicles per hour, while it reaches 100 vehicles on the central accessing segment of Av. Independencia. To put this in terms of service frequency, the headway is one vehicle every 28 seconds on Avenida Almirante Barroso and every 36 seconds on Avenida Independencia. This means a relative ease-up for the on-schedule trunk bus service on the former avenue. The trunk bus traffic from Sao Braz Terminal further into the Centro totals 78 vehicles per peak hour, and increases to 123 vehicles on Avenida Marechal Hermes by joining with the traffic that reaches the Centro via Avenida Independencia. Of 78 vehicles passing Avenida Almirante Barroso, 50 trunk buses stop at Sao Braz Terminal to return to their respective terminals of origin. Similarly, 55 of 100 trunk buses on Avenida Independencia turn back at Avenida Visconde de Souza Franco to return to their respective terminals of origin.

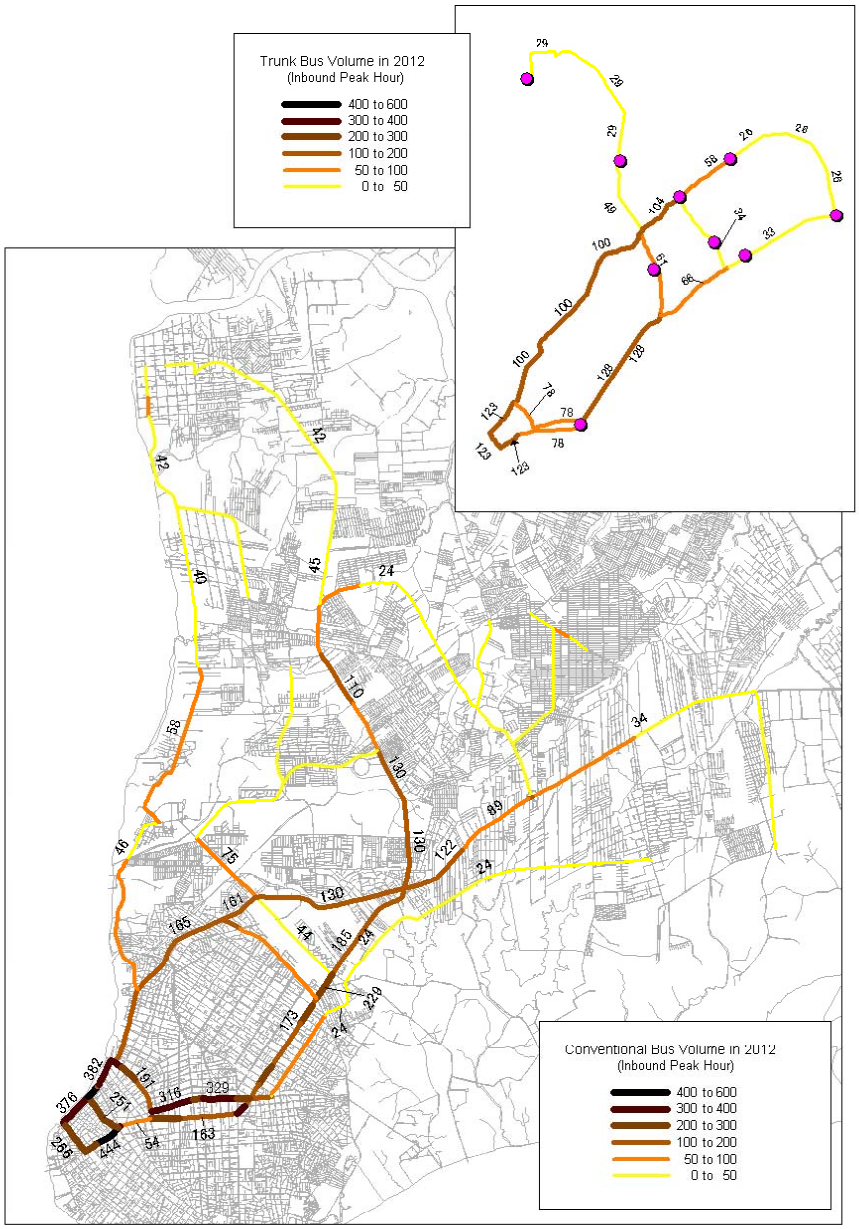


Figure 3-13 Peak Hour Inbound Trunk and Conventional Bus Traffic in 2012

(4) Bus Volumes on Avenida Almirante Barroso

Table 3-5 shows the bus volumes on Av. Almirante Barroso in 2002, 2007 and 2012, whose figures show the heavy bus volumes on this road. The conventional bus volume in 2002 is 610 vehicles per hour, while it reaches 640 vehicles in the "without" trunk bus system in 2007. Since this volume means the headway of 5.6 seconds, this would make it very difficult to operate a bus service. In "with" case in 2007, the trunk bus and conventional bus volumes are 150 and 250 vehicles per hour. The trunk buses operate on the segregated busway with the headway of 24 seconds.

The impact of the absence of the Centro accessing segment on Av. Independencia on the proposed trunk bus system in 2012 is analyzed to show its crucial importance. Without the

segment, the peak hour inbound bus traffic on the avenue consists of 170 trunk buses and 260 conventional buses in 2012. With the segment, the traffic drops to 130 trunk buses and 230 conventional buses. As shown in Table 3-5, the inbound traffic of 170 trunk buses on a single lane means the headway of 21 seconds. Allowing for the time necessary for boarding and alighting and waiting at traffic signals, this would make it very difficult to keep the on-schedule service.

Therefore, it is necessary to verify the bus flow conditions on Av. Almirante Barroso on the trunk bus system, taking into account dwelling time at bus stops and behavior at signalized intersections. And then, the bus operation performance is simulated on a computer by means of a simulation model.

According to the analysis with the simulation model, the trunk buses are smoothly operated on the segregated busway in both 2007 and 2012 in the With case, while traffic of private vehicles and conventional buses on mixed traffic lanes is somewhat heavy. On the other hand, in the Without case the bus density on the road becomes higher according to those years and the buses occupy two lanes on the road.

The conclusion of analysis is as follows.

1) Until 2007, the construction of trunk bus system on Av. Almirante Barroso- BR-316 and Rod. Augusto Montenegro is indispensable for the efficient bus operation.
2) Until 2012, the implementation of the Centro accessing segment of Avenida Independencia is indispensable.
3) Under the current bus system (in the "without" project case), those future bus volumes on the heavy traffic segment on Av. Almirante Barroso will reach critical density. The current bus system is close to its limits in near future.

Table 3-5 Bus Volumes on Avenida Almirante Barroso

(Unit: Number of Bus Volumes/Inbound Peak Hour)

Year	2002	2007		2012		
Types		Without Trunk Bus System	With Trunk Bus System	Without Trunk Bus System	With Trunk Bus System*	Without Centro Accessing Segment of Av. Independencia
Conventional Bus	610	640	250	700	230	260
Trunk Bus			150		130	170
Total		640	400	700	360	430

Note: * With trunk bus system on Av. Independencia

3.4.2. EFFECTIVENESS OF TRUNK BUS SYSTEM

(1) Total Travel Time

Table 3-6 shows total travel time by alternative case. The total time includes the time spent on feeder bus and the waiting time. Trunk buses run on the trunk busway and the exclusive trunk bus lane, while conventional buses use the through traffic lane mixed with private vehicles. The "without" total travel time of Case-2 is 59% longer, and that of Case-3 is 126% longer, than the base year of 2002. The introduction of the trunk bus system lowers the total travel time. The total travel time in the "with" forecast of Case-4 for 2007 is 79% of the time estimated in Case-2. Similarly, the "with" total travel time for 2012 in Case-5 is 69% of the time estimated in Case-3.

The travel time per passenger in 2012 is 54 minutes without the trunk bus system and 38 minutes, or 16 minutes less, with the system.

Table 3-6 Total Travel Time by Alternative Case

Year/Case		Type of Bus Service	Total Travel Time (hours)	Share (%)	Ratio to Without Forecast	Travel Time per Passenger (minutes)
2002	Case-1 Without	Conventional	124,271		–	28.1
2007	Case-2 Without	Conventional	197,149		1.00	41.2
	Case-4 With	Trunk	43,106	28	–	–
		Conventional	113,500	72	–	–
		Total	156,606	100	0.79	32.7
2012	Case-3 Without	Conventional	280,358		1.00	53.5
	Case-5 With	Trunk	72,542	37	–	–
		Conventional	122,175	63	–	–
		Total	194,717	100	0.69	37.2

(2) Impact on Transportation in BMA

The impact of the introduction on the other modes of transport, such as conventional buses and private vehicles as well as trunk bus is analyzed in this Section.

Figure 3-14 shows the ratio of total traffic volume to total road capacity in the entire study area. Without the introduction of the trunk bus system, the volume to capacity ratio reaches nearly 1.00 by 2012. With the introduction, the traffic conditions for conventional buses and cars are significantly improved, with the volume to capacity ratio lower by almost 30% in the same year. The volume to capacity ratio is consistently favorable for the trunk bus traffic over the period.

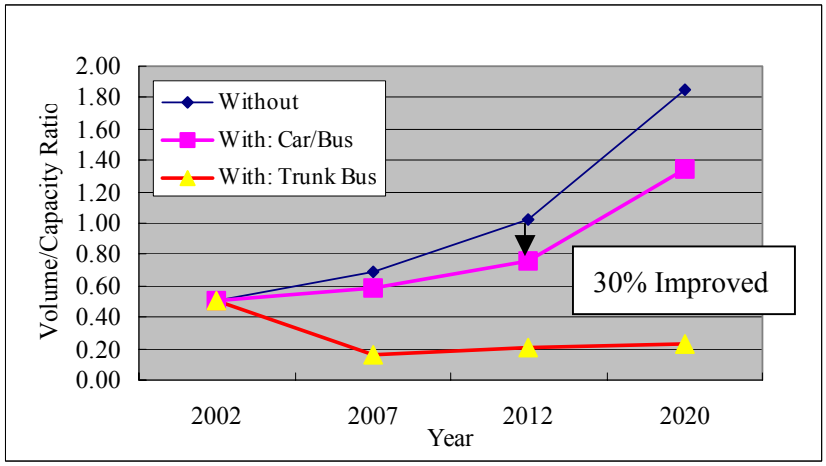


Figure 3-14 Volume to Capacity Ratio in the Study Area by "With" and "Without" Case

(3) Impact on Avenida Almirante Barroso

Figure 3-15 shows the level of congestion by the ratio of average traffic volume to road capacity on Avenida Almirante Barroso. Specifically, the volume to capacity ratio pertains to the 5.9km segment from Entroncamento to Sao Braz. In the "without" cases, the level of traffic congestion worsens apace with the growth of demand, as indicated by the volume to capacity ratio reaching as high as 2.0 in 2012. In the "with" cases, the ratio on the through traffic lanes for conventional buses and cars is 1.00 in 2007 and 2012. The ratio is less than

1.0 on the trunk busway over the period. Even if two lanes are used for the exclusive busway, the traffic conditions on the remaining lanes in fact get better for conventional buses and passenger cars.

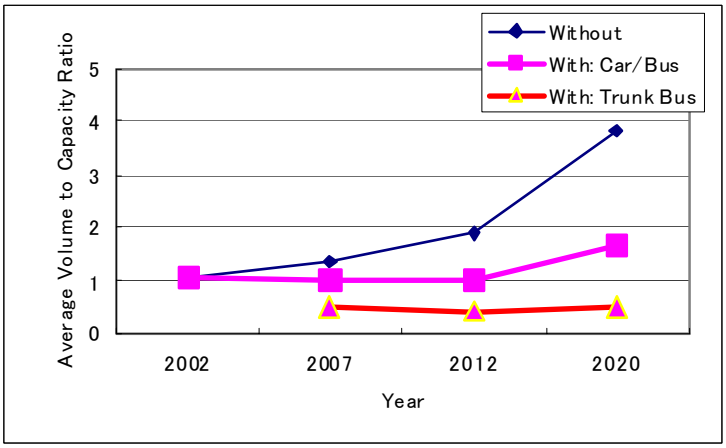


Figure 3-15 Average Congestion on Avenida Almirante Barroso

3.5. TRUNK BUS OPERATION PLAN

3.5.1. OPERATION FREQUENCY BY BUS LINE

In 2007, the headway of two trunk bus lines originating from Terminal A is about 8 minutes each. Two feeder bus lines are in operation, each with the headway of about 3 minutes and their passengers transfer to the trunk bus lines at the terminal. In 2012, four trunk bus lines respectively depart the terminal every 10 minutes or so, while four feeder bus lines are available, each with the headway of 3 to 4 minutes.

In 2007, all of the proposed 14 trunk bus lines run on Avenida Almirante Barroso to access the Centro. The inbound trunk bus traffic is as heavy as one vehicle every 25 to 30 seconds during peak hours. In 2012, Avenida Independencia will be ready to carry part of the passenger load, and the trunk bus traffic on Avenida Almirante Barroso will decline to one vehicle per 35 to 40 seconds despite the expected increase of the total passenger demand.

3.5.2. PROCUREMENT OF NEW BUSES

The proposed trunk bus system will replace 61 of the present 165 bus lines. The future fleet requirements of three bus types on these 61 bus lines are shown in Table 3-7.

Table 3-7 Fleet Requirements by Bus Type

	Conventional Bus		Trunk Bus		Feeder Bus	
	2002	2007	2007	2012	2007	2012
Large Bus	394	446	0	0	0	0
Articulated Bus	0	0	150	213	0	0
Medium Bus (70passgrs.)	0	0	0	0	53	76

3.5.3. FARE SYSTEM

The trunk bus operation will introduce the following fare collection system.

1) Electronic card system will be gradually introduced, however conductor will be still necessary.

2) Passengers board the bus by the front door and get off by the back door.

3) Several types of cards are used in various cities of the world, such as prepaid cards, smart cards, contactless IC cards, credit cards and magnetic cards used per ride. Since the proposed trunk bus system is expected to start its operation in 2007, there is enough time to examine the available options and make the final decision. The future socio-economic prospects of the study area, opinions and attitudes of bus passengers and the management capability of bus companies will have to be closely analyzed to select the most suitable card type.

3.6. PRELIMINARY DESIGN FOR TRUNK BUS FACILITIES

3.6.1. TRUNK BUSWAY

The trunk busway is introduced to three arterial roads of Avenida Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro and the exclusive trunk bus lane to Avenida Independencia (Figure 3-16). The trunk bus priority lane is provided on the selected arterial roads within the Centro and the built-up area of Icoaraci.

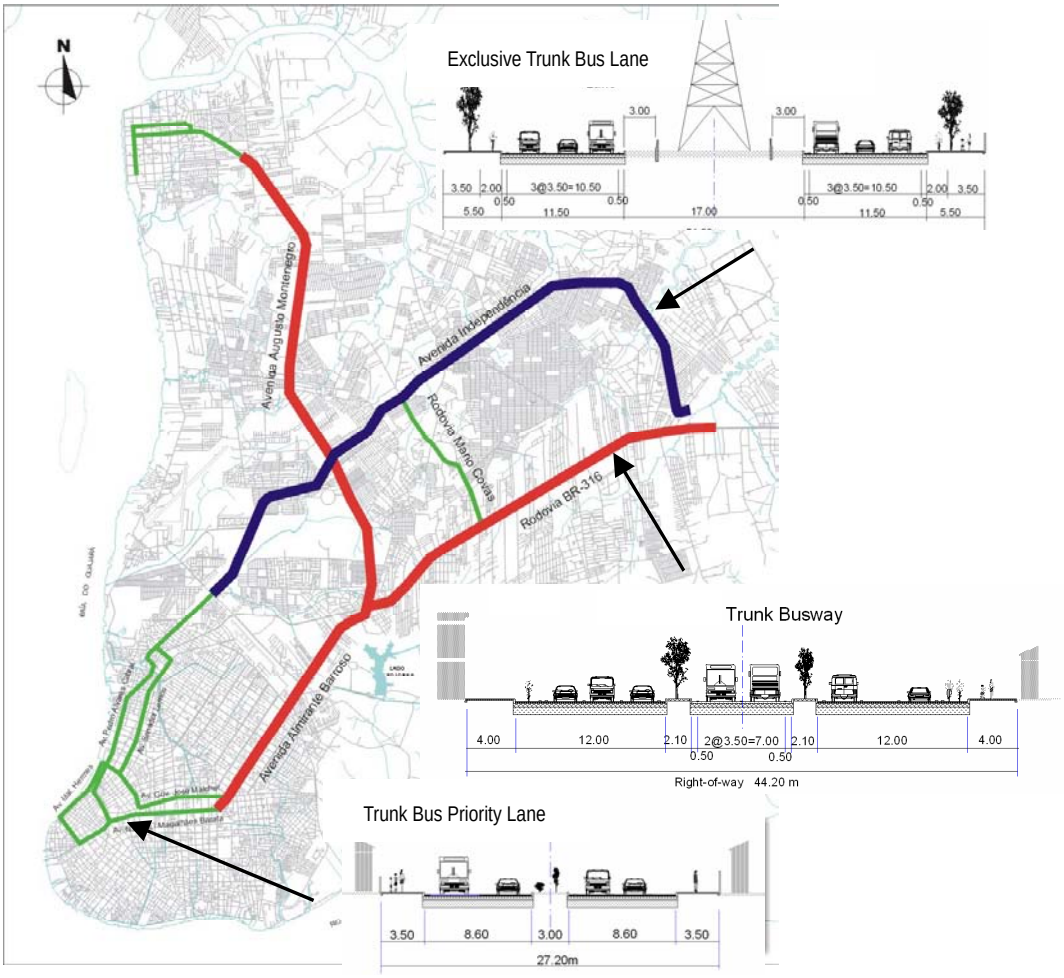


Figure 3-16 Road Network for Trunk Bus System

(1) Trunk Busway

The trunk busway is provided in the right of way of the existing arterial roads. It consists of two lanes, one on each side of the median. Accordingly, the arterial roads must have the width from 42m to 45m and six or more lanes. Figure 3-17 shows the typical cross section on the trunk busway on Av. Almirante Barroso.

The arterial roads are characterized by the intensive roadside development for commercial and residential purposes. Assuming the intensive utilization of the frontage road, the trunk busway is provided in the central part of road space, and segregated by the curb from the through traffic lanes. Other motor vehicles are not allowed to use the trunk busway. To deal with occasions of bus breakdowns, the curb should not be made too high for buses to drive over.

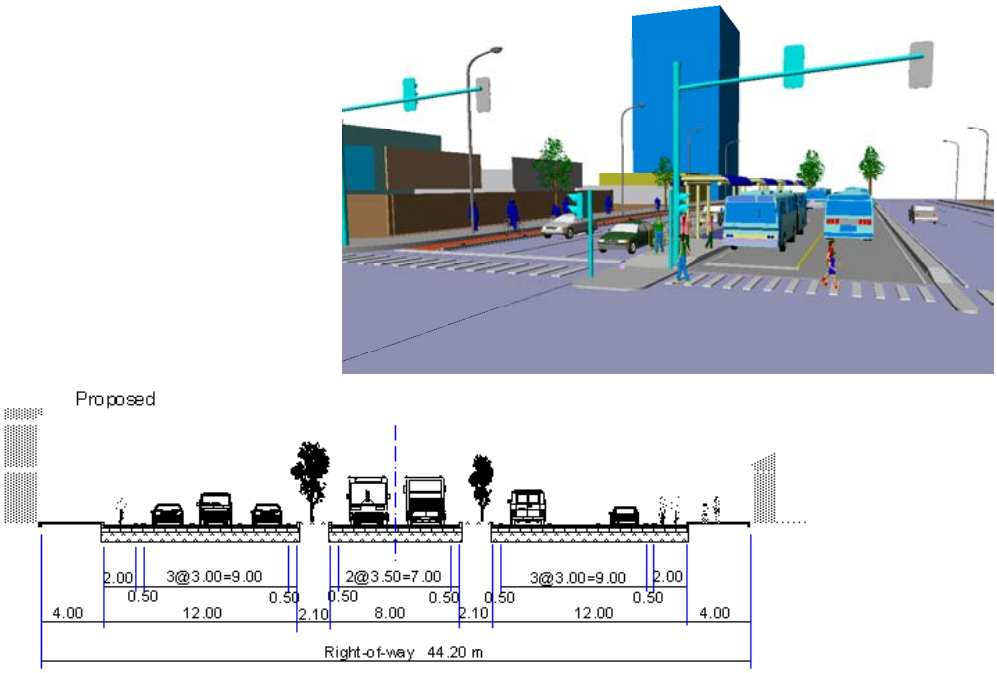


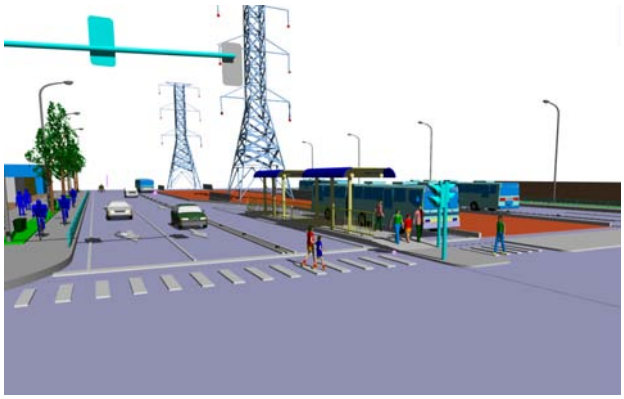
Figure 3-17 Typical Cross Section on Trunk Busway on Av. Almirante Barroso

(2) Exclusive Trunk Bus Lane

The exclusive trunk bus lanes are introduced only on Av. Independencia. As with the trunk busway, the exclusive lanes are provided next to the median. To prevent other motor vehicles from entering, they are segregated by the chatter bar from the through traffic lanes. Figure 3-18 shows the typical cross section on the exclusive trunk bus lane.

(3) Trunk Bus Priority Lane

The right side lane of the existing roads is used as trunk bus priority lane. The lane is marked by the colored pavement to warn off other motorized traffic during the bus priority hours. The lane is open to the regular traffic off priority hours. Figure 3-19 shows the typical cross section on the trunk bus priority lane.



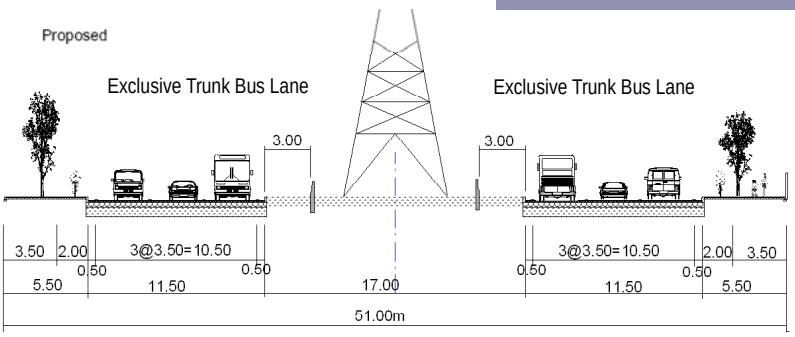


Figure 3-18 Typical Cross Section on Exclusive Trunk Bus Lane on Av. Independencia

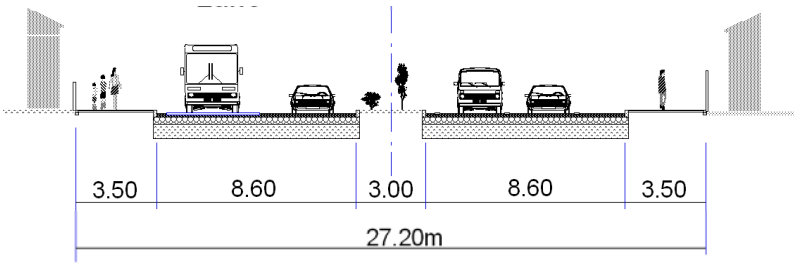


Figure 3-19 Typical Cross Section on Trunk Bus Priority Lane

3.6.2. INTEGRATED BUS TERMINALS

(1) Characteristics of the Integrated Bus Terminal

In general, the major function of a bus terminal is concentration of ends of bus routes, getting on or off buses from various destinations. The one-sided berths or platforms are laid out in parallel maximizing the number of berths and making no crossing of the courses

of buses (like the existing São Braz terminal). Figure 3-20 shows the basic policy of the integrated bus terminal.

The characteristic of the integrated bus terminals is transfer between the trunk buses and the feeder buses. To minimize the time and trouble of the transfer of passengers, it is proposed to choose the platform with two sides, with the buses facing each other for alighting from feeder buses and boarding trunk buses, or vice versa. The risks of crossing bus courses, and crossing bus and passenger traffic should be minimized by necessary means such as pedestrian crossings and manual direction of traffic.

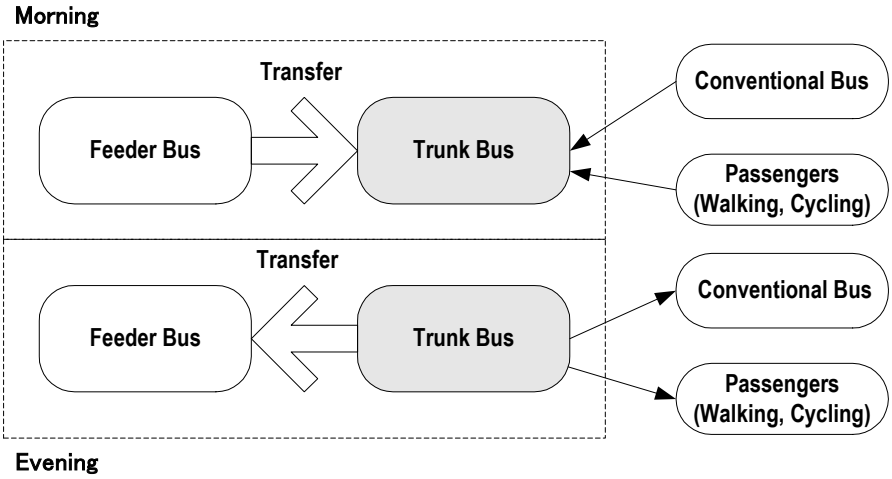


Figure 3-20 Basic Policy of Integrated Bus Terminal

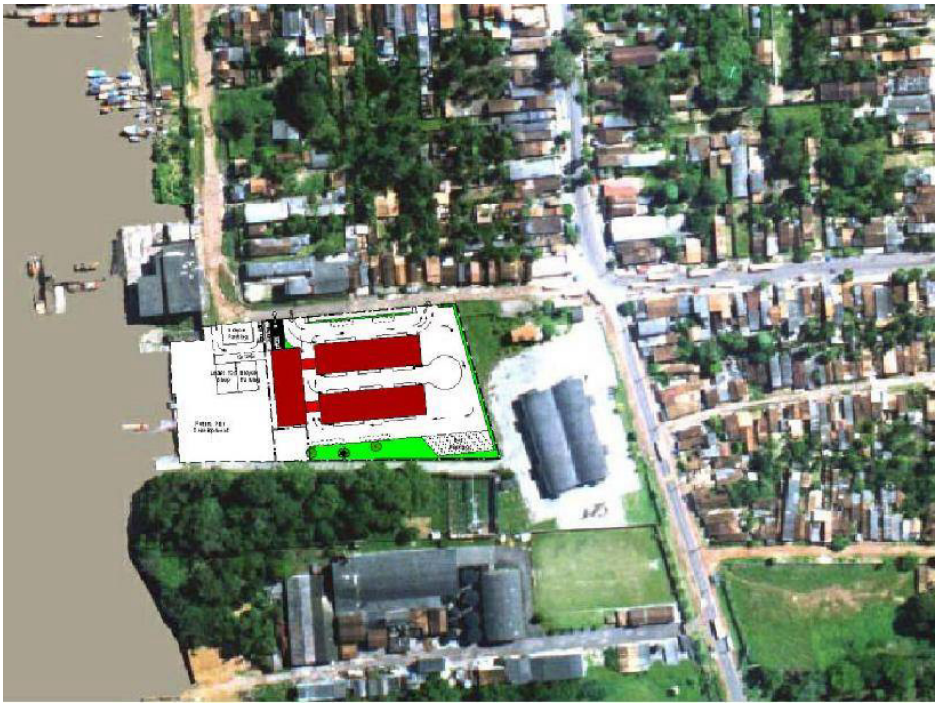
(2) Plan of Terminal A: Icoaraci

Out of eight (8) integrated bus terminals, plan of Terminal A: Icoaraci, is shown in Figure 3-21. The site faces the river and a pier development is planned. The passenger building will be made on the riverside considering the connection to the future pier. The entrance for the passengers and taxis will be at the northwest corner. The entrance for the buses will be just east of this exit, and the exit will be located at northeast. Bicycle parking and a taxi stand will be on the west of the site, which will be reconstructed with the pier development. The parking area for the feeder buses will be made on the south of the site.

3.6.3. TRUNK BUS STOPS

The bus stop on busway should be located just before a pedestrian crossing so that the following bus could queue. Bus stops are constructed on the right side of the busway (buses normally have their doors on the right side of their body). Each stop has a platform of 2.5m in width and 40m to 50m in length (to accommodate two articulated buses simultaneously). The platform is elevated by 15cm from the busway surface level. The trunk busway is segregated from the through traffic roadway by the concrete divider of 1.1m to 1.7m in width, which is used as part of the bus stop platform.

The roof will cover the platform. The side wall will separate the waiting space from the carriage way. The bench will be attached on the wall. Figure 3- and Figure 3-23 show the plan of the bus stop on the busway.



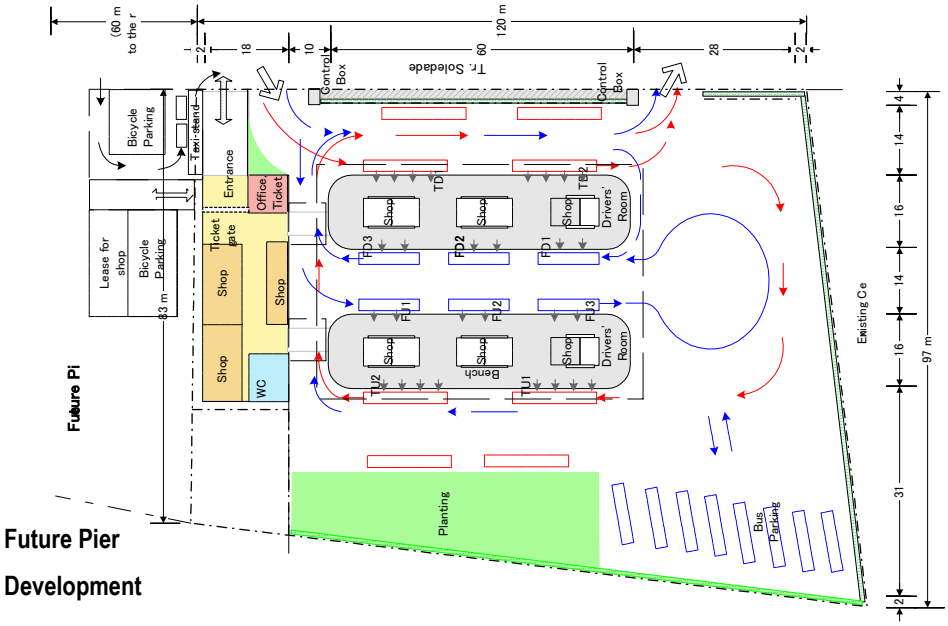


Figure 3-21 Plan of Terminal A: Icoaraci (not to scale)

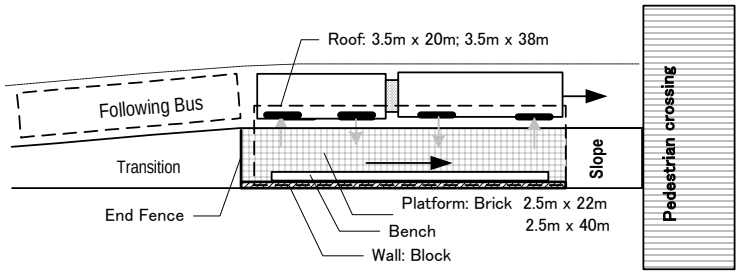


Figure 3-22 (1) Plan of Bus Stop on Busway (One-Bus Stop)

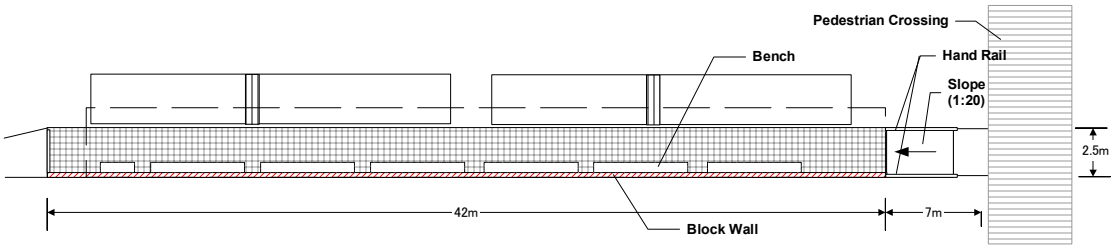


Figure 3-22 (2) Plan of Bus Stop on Busway (Two Bus Stop)

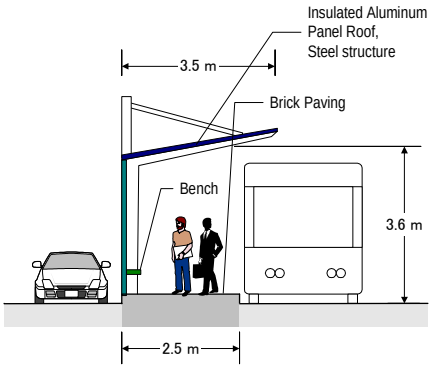


Figure 3-23 Section of Bus Stop (Shelter on Busway)

3.7. ORGANIZATION OF THE TRUNK BUS SYSTEM

3.7.1. CURRENT ORGANIZATION OF THE BUS SYSTEM

There are now three organizations related to the management of the bus routes operated in the BMA, as shown in Table 3-8. CTBel controls the municipal bus routes, besides the metropolitan routes that come into Belem from Ananindeua, Marituba and Benevides. DEMUTRAN controls the internal routes of Ananindeua Municipality. The related municipalities do not control the inter-municipal bus routes; the management, planning and supervising of those routes are under control of CTBel under a partnership agreement. ARCON controls routes of the inter-municipal bus system in the BMA with different tariffs and services.

CTBel controls 88% of the lines, including municipal lines of the capital, and metropolitan lines connecting Belem with the other municipalities in the region. Despite its dominant position, CTBel, created in December 1989, does not yet satisfactorily manage this system, especially concerning the constitution of legal instruments for delegation of services, the quality of its material resources and the qualifications of its personnel.

Table 3-8 Bus Organizations in the BMA

Name	Abbreviation	Administration	No. of Routes	Effectuation Date
Transport Company of Belem Municipality	CTBel	Belem Municipality	152	12/28/89
Municipal Department of Transport and Traffic	DEMUTRAN	Ananindeua Municipality	13	07/24/99
State Agency for Regulation and Control of Public Services	ARCON	State of Para	8	12/30/97

3.7.2. PROPOSAL OF ORGANIZATION FOR THE TRUNK BUS SYSTEM

A new organization will be proposed for the bus system of the Belem Metropolitan Area (BMA), focusing on the following aspects:

- The metropolitan integrated management model; and
- The model for operation of the trunk bus system.

(1) The Metropolitan Integrated Management Model

It is recommended to implement a transition model, in which implementation activities of the Study projects are separated from the management activities of the existing public transport system. Therefore, it will be necessary to create an Executive Transport Group (GET) for the implementation of the Study projects, while existing executive organization continues with its management functions. To articulate the activities of both organs, it will be necessary to organize a Metropolitan Urban Transport Council (CMTU), in accordance with the scheme shown in Figure 3-24.

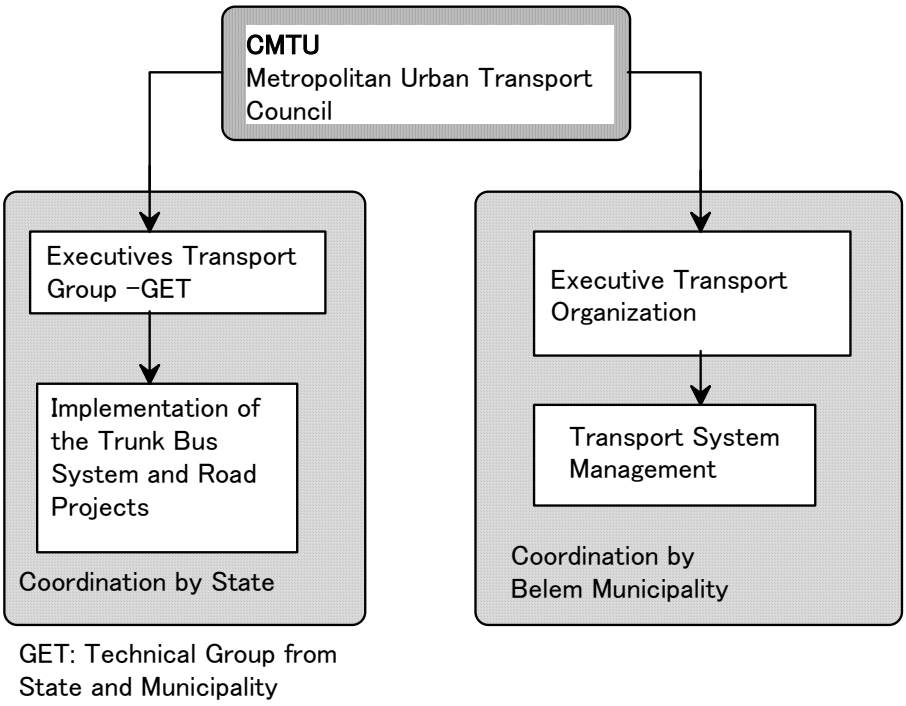


Figure 3-24 Proposed Organization of Trunk Bus System

The CMTU will have an important role of articulation of GET with CTBel to avoid the confrontation with them in the implementation stage of the project when the GET and CTBel propose different proceedings. This council should have the participation of the government of the state, of the municipal government of Belem, of the other city halls of the municipalities that make up part of the BMA, of class entities representative of the different social segments, and of the bus operating companies.

The Executive Transport Group (GET) will be a temporary organization to implement projects and the Regional and Urban Development Executive Office (SEDURB) in the Para State will play a key role. The GET shall be administratively linked to the state and should have its actions subordinated to the Metropolitan Urban Transport Council (CMTU), operating as an executive secretariat of the same. The GET will be responsible for the implementation stage. After the end of this stage, the GET will become the Metropolitan

Managing organization or its technical team will be absorbed by the future metropolitan managing entity.

(2) Model for the Operation of the Trunk Bus System

The basic idea for the arrangement of the companies that operate in the trunk bus system is to group them in associations of trunk bus operators. The premises of which are:

- The companies that make up the *consortium* operate in *isolated geographic areas* (basins). Overlapping of the lines of different consortia occur only in the areas close to downtown.
- The management of the operation of each consortium is *centralized*, and seeks harmony among the different operating companies and maximum rationalization in the rendering of the service.
- In each consortium the companies operate as if they were a single entity, acting as individual, isolated companies in their internal activities, i.e., in the maintenance, in the purchases, and in the administrative routines.
- There are financial compensations among the consortia. The areas (set of lines/companies) with the best financial results transfer funds to those with more modest results. The calculations of the debits and credits of each consortium are made by the local managing entity, and the transfers of funds are promoted by the operating companies' union, which centralizes the income that originates from the advance sales of tickets.

For the case of the Belem Metropolitan Area, there are two suggested alternatives:

1) Consortium of Companies;
2) Consortium of Lines

1) Consortium of Companies

In the consortium of companies there would be involved all the operators that have integrated or conventional lines in the area of influence of the two trunk corridors, in addition to the companies that happen to operate the trunk lines. In that way, two consortia would be created, A and B, that correspond respectively to the trunk corridors of the Rodovia Augusto Montenegro and of BR-316.

It is possible to conclude that the alternative of organization by consortia of companies is difficult to implement, because it is practically impossible to operationally isolate sets of lines and, consequently, of entrepreneurial interests. That alternative would be feasible only with an extensive restructuring of the whole system of bus lines and operating companies of BMA, which might be made feasible only through a bidding process.

2) Consortium of Bus Lines

In the consortium of bus lines there would be involved only the lines that happen to be integrated in order to make up the trunk bus system, including the trunk bus lines themselves.

4. ROAD PROJECTS

4.1. EXISTING ROAD CONDITIONS

There is only one arterial road link each from Centro to Icoaraci and Ananindeua, namely, Rodovia Augusto Montenegro for the former and BR-316 for the latter. New residential areas have been developing along these roads. This means that all kinds of trips, be it for local shopping and visiting, commuting, or productive activities (business and commerce), tend to concentrate on the two avenues, causing chronic traffic congestion. Moreover, there is no functional alternative to Av. Almirante Barroso to reach Centro. Urban life and productive activities will be adversely affected, if anything happens on this avenue serious enough to cordon off the traffic.

In Centro area, road network density is relatively high and the one-way traffic regulation is in force. Therefore, two or more lanes are available for one-way traffic. Two arterial roads that connect Centro to the suburbs, namely, Avs. Almirante Barroso and Pedro Alvares Cabral, merge at the Entroncamento intersection, and the capacity of the intersection creates a bottleneck for the traffic from the suburbs. The bottleneck is exacerbated by the fact that there are few alternative road links to the suburbs.

4.2. PRELININARY ROUTE LOCATION STUDY

After the joint fieldwork of Brazilian counterparts and JICA mission members, however, it has been found more realistic to change part of the initially proposed routes for the project roads. The following is a description of partly changed route segments.

(1) Avenida Pedro Miranda

The proposed segment of Av. Pedro Miranda starts from the border between the Centro and the transition area, crosses a civilian airport via underground passage to Rua R. Chermont, and then connects to Rua Yamada and Rod. do Tapana to reach Icoaraci. The proposed underground route segment to cross the airport (Prefeitra de Aeronautica de Belem) to Rua R. Chermont has several bottlenecks. The main difficulties are the construction of an underground tunnel of shallow depth below the civilian airport and lack of space for proper alignment of approach road due to the planned housing. This segment is abandoned accordingly. Figure 4-1 shows the locations of the bottlenecks.

(2) Extension of Primeiro de Dezembro

The fieldwork has found that the following issues are crucial for planning the extension of Av. Primeiro de Dezembro.

1) The segment extending from Av. Primeiro de Dezembro, which is under construction by Belem Municipality, to Auca Viaria, as shown in Figure 4-2 is relocated on the south side, comparing to the initially proposed route location, which is compared and evaluated regarding the compensation for resettlement and the respective positioning in the entire arterial road network.
2) Lago Agua Preta that supplies water to Belem City is located right next to the planned extension route, indicating adverse environmental effects of the project. Figure 4-2 shows the present condition of the area around the proposed extension. After close consultations with the Executive Secretariat of Science, Technology and Environment (SECTAM) of the Para State, the present Study proposes an elevated type of road structure in the area.

3) As shown in Figure 4-2, the household sewage in the area is discharged through simple drainage ditches and natural streams from north to south. The road embankment, if proposed for the route segment, might force the sewage discharge into the nature reserve. In such a case, it is necessary to provide some drainage structure below the embankment. The examination of this issue was done during the preliminary engineering design stage.

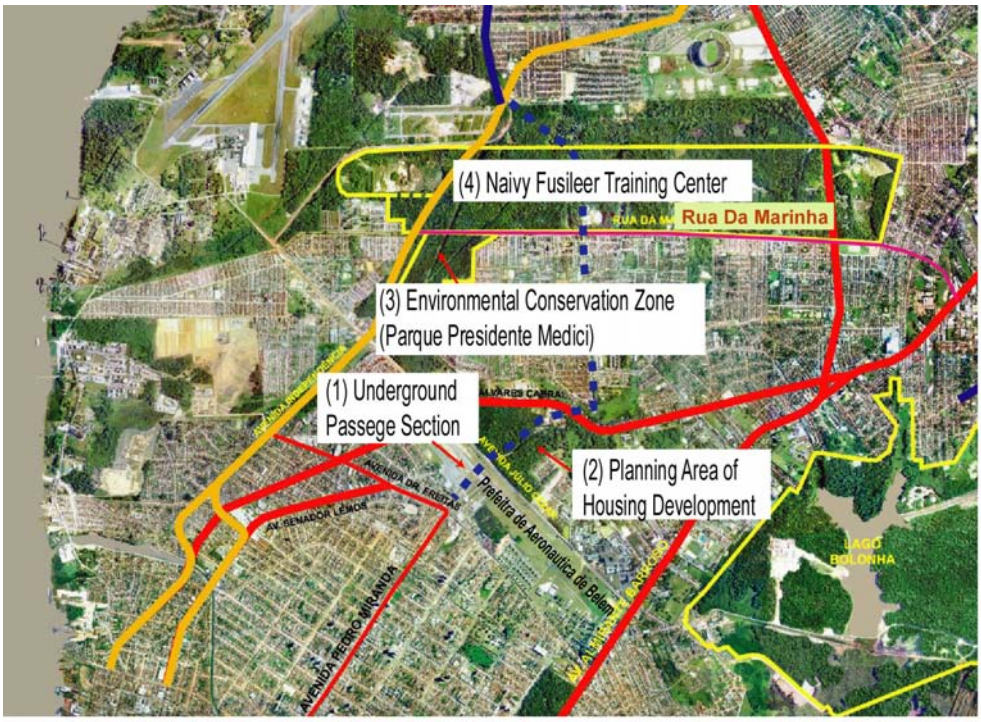


Figure 4-1 Abandoned Route Segment on Av. Pedro Miranda

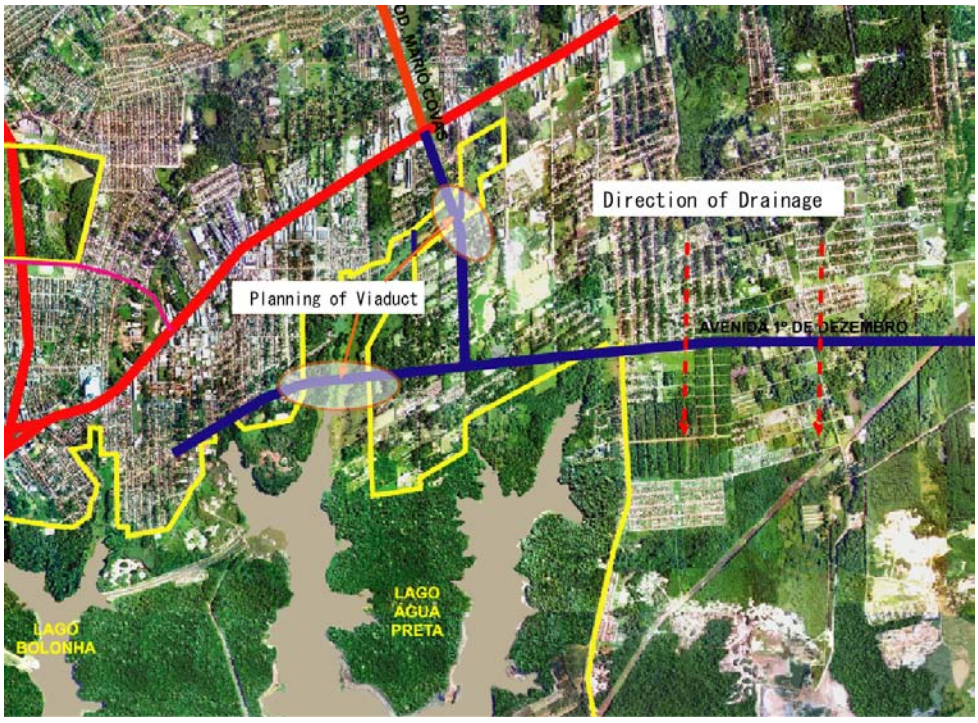


Figure 4-2 Present Condition around the Av. Primeiro de Dezembro Extension

(3) Avenida Mario Covas Extension

In order to strengthen the arterial function of Av. Primeiro de Dezembro in the road network, it is considered necessary to link the said road to BR-316 and extend further to Cidade Nova. It was initially proposed to improve Rua Jardim Providencia and Rua Osvaldo Cruz as one-way traffic roads. From the viewpoint of the arterial road network in this part of the study area, it appears more effective to utilize Avenida Mario Covas for linking Av. Primeiro de Dezembro to BR-316. Rua Ricardo Borges, which is a existing 2-lane road, is utilized as the extension route.

(4) Avenida Independencia

The fieldwork has found that the route origin within the Centro has to consider the several issues for planning (see Figure 4-3). The main issues are the difficulty of traffic management at intersection of five roads, Av. Pedro Alvares Cabral and Rodovia Arthur Bernardes, and requirement of huge cost by a large bridge construction. Therefore, the new route location is planned in the study. The following is the planned location; two one-way roads are being planned on the embankments of the river to connect up the route origin to the intersecting point of Av. Independencia and Rua da Marinha. The outbound traffic on one embankment can be linked to Av. Senador Lemos, whereas the inbound traffic on the other embankment can be linked to Av. Pedro Alvares Cabral. This alternative provides an effective detour to the proposed bridge segment. The location of the alternative is indicated in Figure 4-3.

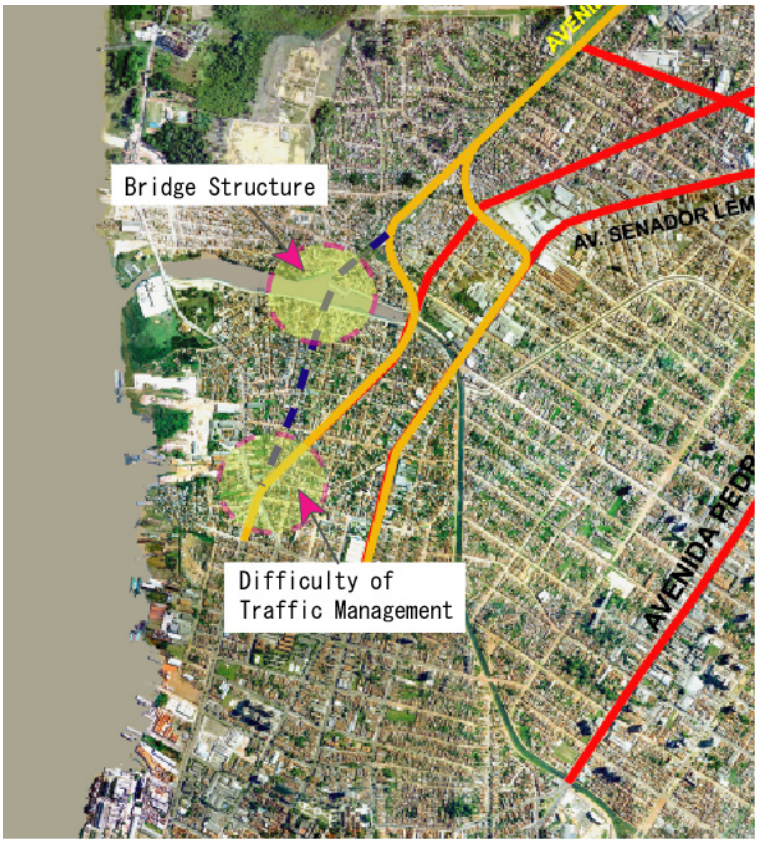


Figure 4-3 Present Condition around Route Origin of Av. Independencia

4.3. PLANNING CONCEPT

(1) Planning Strategy

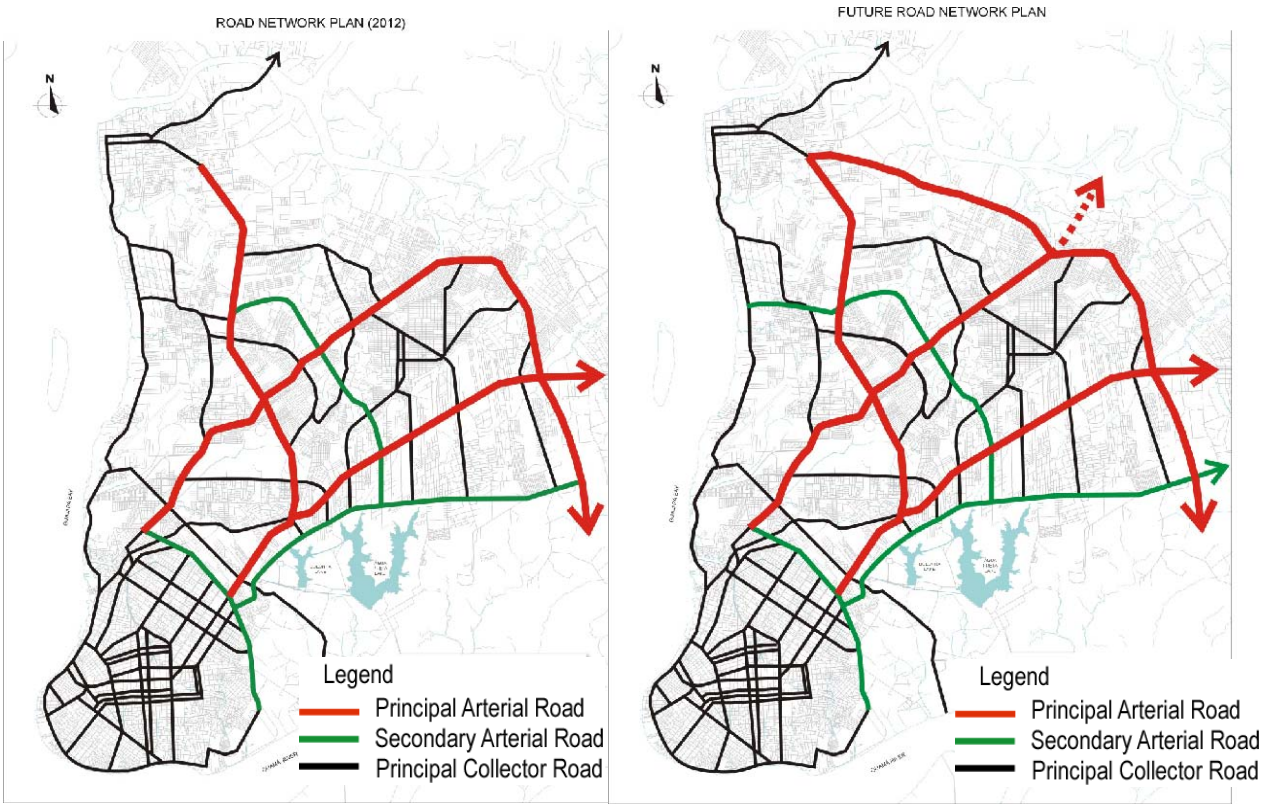
The strategy for road network development must take into account the following issues.

1) Dispersal of traffic flow into Centro and reduction of excessive traffic concentration on certain arterial roads
2) Development of alternative road links to guarantee stable urban life and productive activities
3) Clear hierarchical ordering of urban road functions

(2) Functional Classification of Project Roads

Major radial and ring roads in the BMA are designated either as principal arterials or as secondary arterials. The roads within Primeira Legua Patrimonial are functionally classified by noting continuity, road width and traffic management requirement. Figure 4-4 schematically maps the functionally classified future arterial road network in 2020 as proposed in PDTU2001.

Of the future arterial road network proposed for the year 2020, construction works are now underway on two radial roads. By the year 2007, the segment from Arca Viaria to Rodovia Augusto Montenegro will be completed on Av. Independencia, and the segment from the center of Belem City to the city limit will be completed on Av. Primeiro de Dezembro. By 2012, the target year of the present Study, the PDTU2001-proposed arterial road network will be completed except for some segments of ring roads, as shown in Figure 4-4.



(2012 Network) (2020 Network)

Figure 4-4 Future Road Network Plan in 2012 and 2020

(3) Road Design Standard

Road designs conform to the DNER standards (Normas para projecto das estradas de rodagen, or NORMA for short). The present Study aims to keep the uniformity of design criteria by following the DNER design standards as much as possible. Table 4-1 summarizes the design criteria used for road projects.

Table 4-1 Design Criteria and Required Facilities for Road Projects

Name of Project Road	Road Functional Classification	Design Standards	Type of Project	Design Speed (km/h)	Required Facilities for road and Cross Section Elements						Land Acquisition Conditions
					On-Road Parking	Bike Road	Sidewalks	Wide of Lane (m)	Number. of Lane	Median Strip	
1. Av. Alminante Barros	Principal Arterial	Class-II	Trunk Busway Introduced	70	Prohibited	Provided	Provided	3.50	6	Provided	No Needed Land Acquisition
	Collector	Class-IV	Trunk Busway Introduced	60	Prohibited	Provided	Provided	3.00	6	Provided	
2. Rodovia BR -316	Principal Arterial	Class-I	Trunk Busway Introduced	100	Prohibited	Provided	Provided	3.50	6	Provided	No Needed Land Acquisition
3. August Monteneguro	Principal Arterial	Crass-II	Trunk Busway Introduced	70	Prohibited	Provided	Provided	3.50	6	Provided	No Needed Land Acquisition
4. Av. Independencia	Principal Arterial	Crass-II	Widening of Existing Road (4 to 6 -lane)	70	Prohibited	Provided	Provided	3.50	6	Provided	Under Construction Needed Land Acquisition Compensation
	Collector	Class-III		60	Prohibited	Provided	Provided			Provided	
5. Av. 1 De Dezembro	Secondary Arterial	Crass-II	New Road Construction	70	Prohibited	Provided	Provided	3.50	4	Provided	Needed Land Acquisition Compensation
6. Rod. Mario Covas	Secondary Arterial	Crass- II	New Road Construction	60	Prohibited	N ot Provided	Provided	3.50	4	Provided	Needed Land Acquisition Compensation
7. Rua. Yamada	Collector	Crass- IV	New Road Construction	40	Allowed	Not Provided	Provided	3.00	4	Provided	Needed Land Acquisition Compensation
8. Ruada Marinha	Principal Collector	Crass- IV	Widening of Existing Road (2 to 4-lane)	60	Allowed	Not Provided	Provided	3.00	4	Provided	Needed Land Acquisition Compensation

(4) Road Planning Policy

The following is the description of the basic planning policy for the road projects that include construction, improvement and widening.

1) The improvement on Av. Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro is done within their existing roadways, except at interchanges.
2) The widening on Av. Independencia conforms to the on-going project.
3) The improvement on Rua Yamada is done within its existing right-of-way width to the extent possible.
4) The improvement on Rua da Marinha tries to minimize its impact to the roadside residential areas.

(5) Intersection Planning Policy

Taking note of the DNED's guidelines, the basic planning policy of the Study is described as follows.

1) Intersections of two arterial roads are in principle grade-separated.
2) Intersections of an arterial and a collector, or of two collectors are either grade-separated or at grade.
3) At-grade intersections are provided between two local roads.

There are 18 major intersections in the Study Area, as shown in Figure 4-5, and thirteen of them require improvement of one kind or another as part of the project roads under study. The intersections of two arterials are in principle grade-separated. The appropriate access method to each intersection is examined vis-à-vis the volume of intersecting traffic forecast for 2012.

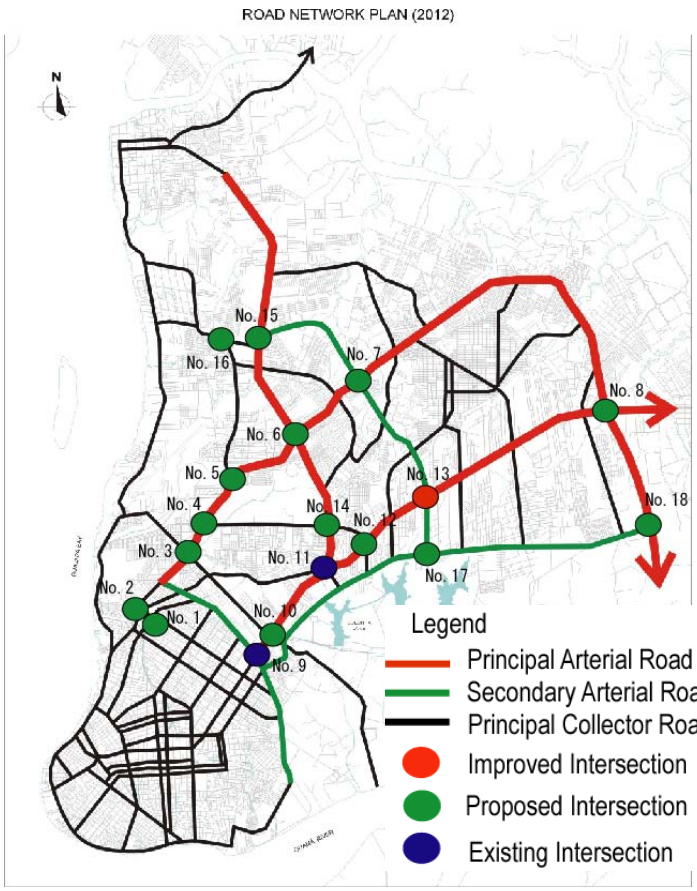


Figure 4-5 Location of Major Intersections under Planning

4.4. PRELIMINARY DESIGN FOR ROAD PROJECTS

4.4.1. AV. PRIMEIRO DE DEZEMBRO

(1) Alignment and Cross Section Designs

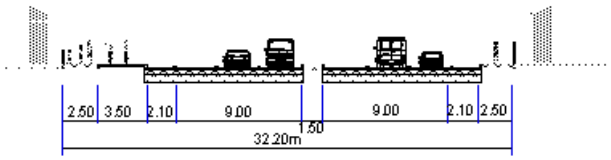
Design conditions for vertical alignment are as follows.

a) Because the road goes through the expanding residential areas, the design follows, as much as possible, the existing vertical alignment of the road.

b) The steepest longitudinal slope is 1.0%.

The cross section design adopts the road width of 40.0m, expecting the future widening to six lanes from the proposed four lanes. The four-lane road segment originating in the eastern edge of the Centro is now under construction by the Belem municipality. Figure 4-6 compares the typical cross sections of the on-going and the proposed projects.

Existing (Under construction)



Proposed Plan

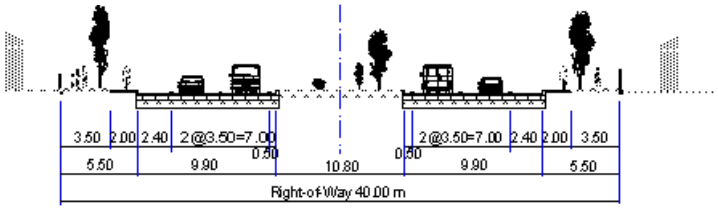


Figure 4-6 Proposed Cross Section for Av. Primeiro de Dezembro

(2) Drainage Design

To protect the natural environment around the reservoir on the south, the proposed road fills the role of partly checking the household waste water from the northern residential areas from seeping into the reservoir.

The outline of proposed drainage plan is as follows.

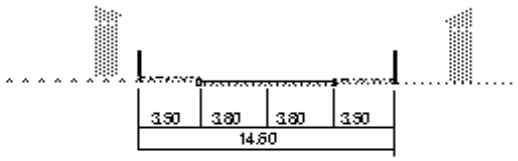
a) Near the origin of the proposed road, the water is drained off from the direction of BR-316 toward the reservoir.

b) Around the other end of the road, the water is drained off toward BR-316.

4.4.2. RUA YAMADA

Based on the traffic forecast through 2012, it is considered necessary to widen Rua Yamada into two-way four-lane road with the right of way width of 27.2m. Figure 4-7 compares the present and the proposed cross sections. The widened road consists each way of the sidewalk of 3.50m, the parking belt of 2.10m and the secondary-arterial-class roadway of two 3.0m lanes. The left-turn lane of 3.0m is provided next to the median.

Existing



Proposed Plan

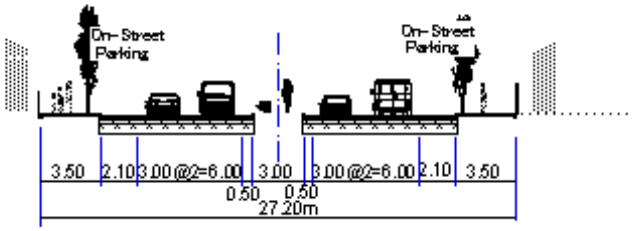


Figure 4-7 Proposed Cross Section for Rua Yamada

4.4.3. RUA DA MARINHA

(1) Alignment and Cross Section Designs

The design is aligned with the centerline of the existing road, extending to the intersection with Alameda Mosa Bonita. The design follows the existing vertical alignment of Rua da Marinha. The steepest longitudinal slope is 0.74%.

The necessary widening is extended into the abutting naval property on the north. Figure 4-8 compares the present and the proposed cross sections of the road. The new road consists each way of the sidewalk of 2.4m, the bikeway of 2.0m, the parking belt of 2.10m and the secondary-arterial-class roadway of two 3.0m lanes. The left-turn lane of 3.0m is provided next to the median.

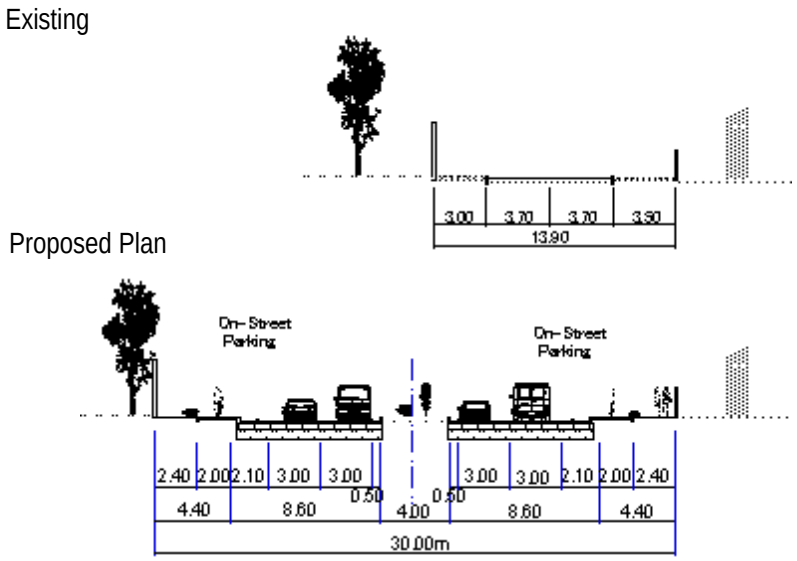


Figure 4-8 Proposed Cross Section for Rua da Marinha

(2) Drainage Design

Rua da Marinha skirts around the periphery of Parques Presidente Medici, the nature conservation area. Therefore, drainage structures and appurtenances are so designed to minimize the adverse effects on local fauna and flora. Due attention to the local natural habitat or ecosystem is needed from the planning stage through the operation and management. The road planning and design takes into account the following environmental precautions.

1) Attention to natural plant and animal life
2) Improvement on the natural environment
3) Mitigation measures during and after the road construction

5. CONSTRUCTION PLANNING AND COST ESTIMATE

5.1. CONSTRUCTION PLANNING

(1) Busway Project

Since the construction work is to be carried out on the existing roads under heavy traffic, it is most advisable to select construction methods to avoid interference with traffic and to minimize the construction period and cost. The major construction method for the trunk busway will include the following work:

- To remove the existing center median and bikeway
- To excavate, lay geotextile and backfill with selected material
- To lay and compact new sub-base and base course
- To provide drainage and median
- To pave the new trunk busway with concrete
- To build bus facilities such as bus stops
- To additionally overlay new pavement on the remaining section
- To demolish existing pedestrian bridges and build new pedestrian bridges
- To mark lanes

(2) Road Project

On Av. Primeiro de Dezembro, the project is an extension road and a new construction road with pre-stressed hollow slab bridges. The major construction methods in the projects consist of the following major work:

1) Road segment:
   - To grub and clean the sites
   - To excavate, lay geotextile and backfill with selected material
   - To lay and compact a new sub-base and base course
   - To provide concrete curbing, drainage and median
2) Bridge:

   The substructure construction procedure will include the following:
   - To drive steel piles or reinforcement piles
   - To excavate the foundation after all the piles are driven
   - To place blinding concrete, and to treat pile heads
   - To assemble reinforcing bars and formwork for structures as abutments and piers
   - To place concrete in the structures
   - To carry out back-filling

5.2. PROJECT COST

(1) Total Project Cost

The project cost consists of direct construction, indirect construction, engineering service, contingency, land acquisition and administration costs. Most of these costs are estimated based on the unit cost of work items obtained from a unit price analysis and in comparison with costs of similar projects in Belem Municipality. The estimation of the project cost is based on the results of preliminary engineering design, quantity take-off of each work item, and the construction method.

The fundamental concepts in estimating the project cost are as follows:

a) The unit cost of each component is determined based on the economic condition as of June, 2003 (1US$=2.9 R$, 1US$=120Jyen).

b) Engineering service cost is assumed to be 10% of the construction cost.

c) Contingency is approximated as 15% of the sum total of the construction cost and engineering service cost.

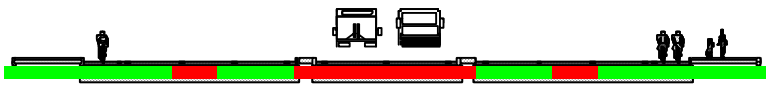
d) Land acquisition and compensation cost is evaluated by a counterpart of COHAB.

e) Administration cost is estimated to be 5% of the sum total of construction cost and engineering service cost.

Table 5-1 shows the total project cost by the With and Without extra works. Figure 5-1 illustrates the extra works composed of overlay of carriage way and sidewalk, and drainage in which the parts of extra works are shown in green color. The total project cost is approximately US$261.5 million including extra works, in which US$163 million are for the trunk bus project, and US$98.5 million are for the road projects. The extra works of trunk busway are estimated about US$27 million. It is equivalent to 27% of the total trunk busway cost.

Table 5-1 Total Project Cost by With and Without Extra Works

Items		(1) Cost including Extra Works	(2) Cost excluding Extra Works	Difference	Ratio (2)/(1)
		Million US$			
(1)	Trunk Bus Project				
	Trunk Busway and Priority Lane	100.7	73.8	26.9	0.73
	Exclusive Trunk Bus Lane	45.8	45.8	0.0	
	Integrated Bus Terminals and Bus Facilities	16.5	16.5	0.0	
	Sub-total	163.0	136.1	26.9	0.83
(2)	Road Projects	98.5	98.5	0.0	
	(excluding Av. Independencia)				
Total Project Cost		261.5	234.6	26.9	0.90



With “Extra Works”; Green color shows the parts of extra works

Figure 5-1 Part of Extra Works

(2) Trunk Bus System Project Cost

Table 5-2 shows list of trunk bus system projects, in which the project volume/length and project cost for each project item are summarized. The total project cost of the trunk bus system is estimated at US$163 million, at 2002 prices, of which US$146 million is for the busway, US$13.5 million is for the integrated bus terminals, and the balance is for bus stop facilities. The equivalent unit cost per the busway length, including the integrated bus terminals and bus stops, is US$2,190,000/km.

(3) Road Project Cost

Table 5-3 shows a list of road projects, in which the project volume/length and project cost by each project item are summarized. The total road project cost in exclusive of the Av. Independencia project is estimated at US$99 million, at 2002 prices, of which US$51.8 million is for Av. Primeiro de Dezembro, US$32,700 is for Rua Yamada and the balance is for Rua da Marinha. The equivalent unit cost per the road length is US$4.00 million/km.

Table 5-2 List of Trunk Bus System Projects

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	17,886
2)	Rodovia BR-316	Trunk Busway	10.750	2	32,439
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	21,551
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	1,225
	Sub-Total		74.384		146,486
2. Integrated Bus Terminals			Area m2		
1)	Terminal A: Icoaraci	Bus Terminal	11,480		1,454
2)	Terminal B: Tapana	Bus Terminal	15,540		2,092
3)	Terminal C: Mangueirao	Bus Terminal	15,540		2,011
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		2,188
7)	Terminal G: Independencia 1	Bus Terminal	10,560		1,118
8)	Terminal H: Independencia 2	Bus Terminal	10,560		1,072
	Sub-Total				13,467
			Number		
3. Bus Facilities (Bus Stops)		Bus Stop	45		
		Bus Shelter	82		3,023
		Sao Braz Terminal Rehabilitaion	1		
4. Total Cost of Trunk Bus System Project					162,976

Table 5-3 List of Road Projects

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	51,796	New construction road
4)	Rua Yamada	10.000	4	32,655	Road Improvement
5)	Rua da Marinha	4.555	4	14,052	Road Improvement
Sub-Total excluding Av. Independencia		24.632		98,503	Only Study Projects
Total		44.211		175,139	

6. ENVIRONMENTAL IMPACT ASSESSMENT

6.1. EIA STUDY

Based on the Brazilian EIA Law, Environmental Impact Assessment (EIA) study of the proposed project is carried out. Within this project, ad-hoc EIA study team, consisting of Counterpart Team, JICA Study Team and Local EIA consulting firm, was assembled at the early stage of this project, and then, the preparation of the environmental license application was initiated.

Basically, Study Team is in charge of technical supervisions and supports of EIA study and takes all responsibility of following subtask items.

1) Preparation of Project Brief.
2) TOR Discussions
3) EIA Study
4) Preparation of EIA/RIMA (D/F) Reports

Followings are major subtasks and the Counterpart team takes all responsibilities,

5) Relevant procedural matters for the license application process.
6) Public Involvement

Besides, until the license is officially approved by SECTAM, the Counterpart also takes all responsibilities of other relevant subtasks and revising work of EIA (D/F) after the assignment of Study Team at Belem is over.

EIA study was initiated after the completion of EIA TOR (Final) on July, 2002, and draft final reports of EIA/RIMA were submitted to SECTAM by the end of February, 2003. Then, the official announcement of the public review was made in the newspaper (DIARIO OFICIAL), dated March 31, 2003.

At the same time, SECTAM assembled five evaluation study teams and started their evaluations of submitted EIA D/F reports. After the public review period was terminated, it was found that SECTAM did not receive any official requests of public meetings/or forums from any organizations/groups/parties and/or individuals. In Brazil, it is not mandatory to have any public meetings when there is no official requests during the public review period. So, SECTAM decided not to have any public meetings/or forums and move forward to next step, final evaluation by Environmental Counsel (COEMA). Whole EIA/RIMA evaluation work by SECTAM was officially terminated in the middle of July, 2003, and the summary of their evaluations are to be sent to COEMA.

6.2. IMPACT ASSESSMENT

Throughout previous initial engineering evaluation of each major roads that consist of entire project routes of new roads and trunk bus system project, several feedback from results of IEE to the preliminary design process were carried out. As a result, several new design concepts, summarized in Table 6-1, were introduced into the final route and design selection for entire project. Then, based on selected best plan of route, road structure and nine associated bus terminal facilities, potential environmental impacts for both construction and operation phases of the project were summarized. This impact assessment study qualitatively describes the direct/indirect, second and/or cumulative impact regarding several key environmental factors.

Table 6-1 Summary of Environmental Feedback from IEE

	Project Route Components	New Plan/Modification
1	Avenida Independencia	Partial route change in order to lessen the impact of cutting through the Environmental Reserve, Presidente Medici II. Mitigation measures such as fence/cage/or animal path to lessen the conflict with fauna were introduced.
2	Rua Marinha	Mitigation measures such as fence/cage/or animal path to lessen the conflict with fauna were introduced. Five Animal Path R$ 12,500 x 5 = R$ 64,500 One Flyover Fence R$ 300,000 x 1 = R$ 300,000 Total R$ 364,500
3	Rua Chermont	Cancelled due to the potential difficulties of large-scale expropriation.
4	Avenida Primeiro de Dezembro	Partial route change in order to avoid cutting through several watersheds near Alca Rodoviaria.
5	Avenida Primeiro de Dezembro	Bridge structure is selected to cross the watershed area of APA Belem, and PC Pile foundation, not CCPP (Concrete Cast-in Place Pile) - type, is to be used to minimize the risk of accidental water quality deterioration during the construction period.
6	Avenida Mario Covas Extension	Same as above

6.3. IMPACT MITIGATION

Based on Impact Assessment Study, mentioned above, the comprehensive, effective mitigation measures for negative impacts for the construction and operation phases of the project were summarized (see Table 6-2 and Table 6-3).

Table 6-2 Summary of Major Mitigation Measures (Bio-Physical Environment)

Element/ Negative Impact	Mitigation Measure
Floods/or inundation	
Local flood/or inundation caused by excessive water blockage of drainage system due to construction work.	Temporary and/or permanent drainage systems are designed to minimize the occurrence of local flood/or inundation and impact on the water quality of several tributaries. Surface run-off water must be collected in sediment ponds. The drainage system must be periodically cleared so as to ensure smooth water flow.
Worsened water quality due to partial diversion of run-off water.	Manage non-point pollution through the application of the best management practices as determined by a state or municipality to be the most effective practicable means of achieving pollutant levels compatible with water quality goals. Use constructed wetlands to control non-point source pollution involving nutrients, pesticides and sediments.
Flora/Fauna	
Destruction of roadside vegetation.	Planting should be done wherever possible with native species which are likely to require little maintenance and may prove beneficial in maintaining ecosystem integrity with coordination of FUNVERDE. Topsoil must be removed, segregated, stored, and redistributed with minimum loss or contamination. Topsoil and subsoil may be removed separately and replaced in sequence. In cases where non-native species are deemed essential, careful monitoring should be planned.
Destruction of natural vegetation.	Planting should be done wherever possible with native species which are likely to require little maintenance and may prove beneficial in maintaining ecosystem integrity with coordination of IBAMA/SECTAM and/or FUNVERDE. In cases where non-native species are deemed essential, careful monitoring should be planned.

Disturbance to birds and wildlife during construction and operation.	Although birds and wildlife (i.e., monkey) may be disturbed during the construction activities, the effect is likely to be very minor, and birds and wildlife will relocate to area further away from the construction site. After construction, birds and wildlife will return, depending on the scale of construction activities. IBAMA/SECTAM and/or FUNVERDE must be consulted. Timing, shaping and sizing operations must be concluded to avoid breeding or nesting season and trees, protecting key food, cover, and water resources. Fencing will keep large mammals from direct contact with toxic chemicals in sedimentation ponds and from roadway to reduce the number of roadkills.
Risk of pollution on aquatic species during construction.	Great care must be taken to ensure that potential contaminants do not enter APA Belem or any other water courses. All chemicals (oil, petrol etc.) must be kept in securely bounded areas with a capacity greater than the volume of chemical to be stored. The concrete batching plant must be located away from the riverbank, and effluent neutralized prior to disposal. Oil interceptors should be used, and oily wastes must be stored to suitable disposal sites. IBAMA/SECTAM and/or FUNVERDE must be consulted. Buffer strips must be left between construction sites and waterways. All streams restoration is to include alternating patterns or riffles, pools, and drops. The Contractor must submit written emergency procedures to be followed in the event of accidental spillage. Risk of water pollution minimized, not eliminated.
Disturbance to animal path after construction	Local ecosystem such as access to drinking and feeding places shall be well-studied. Animal path, fence, and/or cage must be designed to lessen impact of fauna community separation. Create new feeding/drinking sites far distant from roadways. Roadkills by traffic accident decreased, not eliminated. Habitat alternated. Local ecosystem changed.

Table 6-3 Summary of Major Mitigation Measures (Socio-Cultural Environment)

Element/ Negative Impact	Mitigation Measure
Land Take	
Land take due to road alignment along new-road route.	Approximately 1,818 house will be expropriated along the route. Alternative houses/or resettlement sites must be provided prior to the land take. Alternative house shall be located around previous location as close as possible. Appropriate expropriation programs should be prepared.
Historical and Cultural	
Archaeological discovery of potential sites.	New or additional historic properties are discovered, damage to those newly discovered one should be minimized. Typical mitigation measures include limiting the magnitude of the undertaking, modification of undertaking through the re-design, re-orientation of construction, repairing, rehabilitation, or restoration of affected areas, preservation and maintenance operation for involved historic properties, relocation of historic properties and so on. IPHAN/SECULT-DHPAC and FUMBELL must be consulted.
Material Transport	
Increased traffic level during construction for materials transport.	During construction period, trucks delivering materials to site should thoroughly be checked to ensure that they are road worthy and that the brakes are in full working order. Where feasible, trucks should avoid driving through the residential areas. Trucks used for the transportation of material should be routed, where feasible, to avoid residential area. Re-use soil cut from earthwork for new roads construction as much as possible in order to lessen long-distance deliveries.
Preparation of Excavated soil dump site.	Selection of soil dumping sites shall be well-discussed with relevant agency such as SECTAM. Soil dumping sites shall be well spread over entire project site to avoid local traffic congestion.
Noise/vibration	

Noise/vibration transmitted from new roads and bus system.	Vehicular noise can be reduced at source through vehicle construction process, selection of tires and exhaustion system as well as vehicle maintenance. Also, the application of smooth, well-maintained surfaces is effective in reducing frictional noise and vibration. Noise barrier is the most common mitigative measures used. Low noise pavement is also useful mitigative measure. Note building façade insulation such as double window glazing is an option to dampen noise in building. More detailed discussion about noise impact prediction must be carried out.
Air Pollution	
Dust during construction	Vehicles delivering materials should be covered to reduce the spill. Mixing equipment should be well sealed, and vibrating equipment should be equipped with dust-remove device. Wind erosion from open land can be controlled by use of following three basic techniques (watering, use of chemical stabilizers, and wind breaks) in addition to a vegetation cover. Operators should pay attention to their health.
Local air quality degradation around new roads and bus system.	Introduce environmentally-friendly vehicle (e.g., hybrid type vehicle), more sophisticated I/M program, traffic regulation, clean fuel policy and others. It is recommended that air quality environmental standards be adhered to.
Water Resources	
Pollution of existing wells.	Contractor must take adequate steps to prevent pollution, including bounding area at where any hazardous liquids such as oil or petrol are stored. Contractor must submit written details of the procedures to be implemented in the event of pollution incident.
Demolition of shallow wells	New wells and/or alternative water supply system provided.

6.4. VEHICULAR EMISSION STUDY

6.4.1. OBJECTIVES

The purpose of this study is to evaluate the amount of vehicular emission to be generated by the regional future traffic and transport condition in the BMA, and carry out a comparative study under two scenarios (i.e., With and Without cases) in Years 2007, 2021 and 2020. Here, emissions of the nitrogen oxides (NOX) and CO_2 are of concern.

6.4.2. RESULTS AND DISCUSSIONS

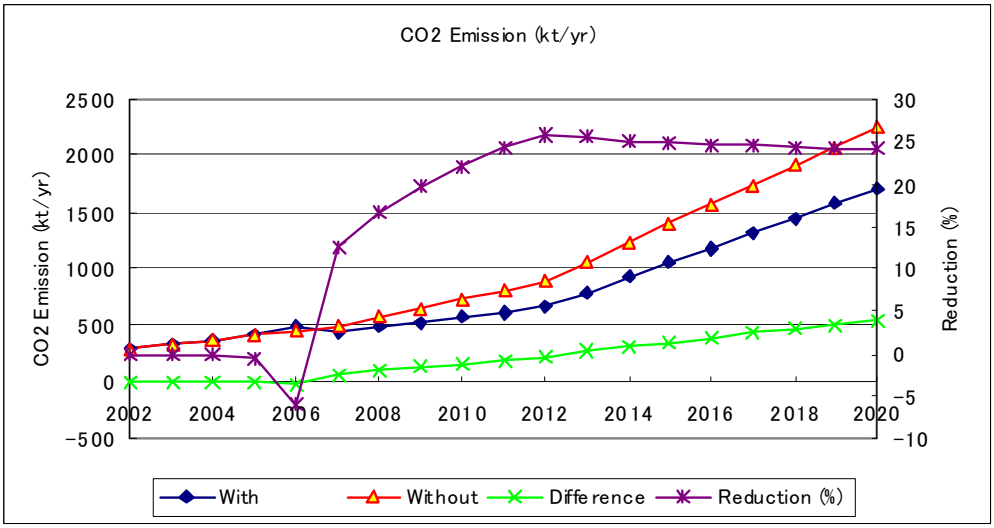
From this study, it was found that 6.82 ton/day reduction (i.e., 19.6 %-reduction) of NOX-related vehicular emission can be expected by the operation of the proposed transport project in Year 2020. Similarly, it is found that 1,740 ton/day reduction (i.e., 24.1 %-reduction) of CO_2-related vehicular emission- can be expected by the operation of the proposed project in 2020.

6.4.3. LIFE CYCLE ASSESSMENT OF CO_2 EMISSION LOADING

Figure 6-1 shows the time variation of annual CO_2 emission loading during Year 2002 - 2020. Here, annual CO_2 emission loading for the With and Without cases is computed based on LCA (Life Cycle Assessment) concept, and computed CO_2 emission loading to be generated by all construction activities such as construction machine operation and material delivery are added to the emission loading to be generated by traffic.

As shown in Figure 6-1, the CO_2 emission loading for the With case becomes higher than that of the Without case at the early stage of construction period. The deficit of CO_2 emission-loading (i.e., the difference of the CO_2 emission loading between both cases) is increased gradually and reaches the highest point in 2006 (the reduction rate is -6.1 %), since most of construction works of the trunk bus system projects are planned to be terminated by the end of this year.

After the operation of the project starts partially in 2007, this deficit is eliminated dramatically and then, turned into the surplus (i.e., the emission loading for the With case is lower than that of the Without case) in 2007. After this, the CO_2 emission-loading surplus increases asymptotically, and reaches highest values around Year 2012 (the reduction rate is 25.8 %).



Note: Reduction (%) = 100.0 x $((CO_2)_{Without} - (CO2)_{With})/(CO_2)_{Without}$

Figure 6-1 Vehicular Emission (CO_2) obtained from LCA

6.5. NOISE PREDICTION STUDY

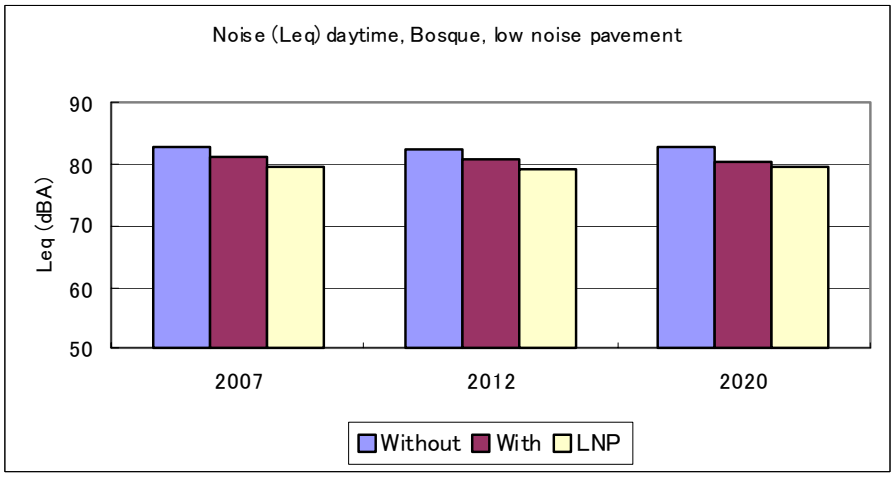
6.5.1. OBJECTIVES

The purpose of this analysis is to evaluate the sound pressure level to be generated by the future traffic and transport conditions along major roads such as Avenida Almirante Barroso, and find out suitable impact mitigation measures within this project. The noise impact prediction study was carried out for the daytime and the night-time transport conditions, respectively. Here, following two noise mitigation measures such as (i) low noise pavement, and (ii) noise barrier, are of concern. However, those mitigation measures were not proposed in the Study because of cost and effectiveness, though those measures take good effect in noise level.

6.5.2. RESULTS AND DISCUSSIONS

In all the Without cases, it was found that both predicted noise levels at Bosque and Sao-Braz exceed the current day-time noise standard of Brazil (60 dBA for the commercial and mixed area). When the proposed project is implemented without any noise mitigation measures, predicted sound pressure levels at both receptor positions tend to be decreased by 2 dBA. This is mainly caused by the re-configuration of vehicle lanes, increasing the physical distance between the centerline of the outermost vehicle lane and receptor position slightly. When the low-noise pavement is implemented within the With case, the predicted sound pressure levels at both receptor sites are decreased by 1.5 dBA further. So, it can be said that moderate noise reduction would be expected by the implementation of the low noise pavement. It is noted that the periodical maintenance activity will be required for this type of the pavement in order to keep high-performance of the pavement structure.

When the noise barrier is installed, predicted sound pressure levels at receptor position height (hp) = 1.2 m are reduced considerably, whereas sound pressure levels at hp = 6.0 m are increased and exceed the current Brazilian noise standard (55 and 60 dBA for the residential, and commercial and mixed area, respectively). These changes are mainly caused by the effect of the diffraction of the noise transmission process. The physical distance between the noise emission source and the receptor with hp = 1.2 m is increased by the noise barrier installation, so considerable noise reduction can be achieved for the ground-level walkers. However, reflected sound energy is shifted toward some directions by noise barrier installation, and consequently the sound pressure levels at some higher places such as the point at hp = 6.0 m are increased considerably. So, it can be said that the noise barrier installation would provide significant roadside noise reduction for ground-level pedestrian but not for the high-story building. Additional mitigation measures such as the building facade insulation would be necessary. Figure 6-2 shows one of major noise prediction results.



Note: "LNP" indicates Low Noise Pavement case.

Figure 6-2 Predicted Leq value (Bosque, Daytime, Low Noise Pavement)

6.6. VIBRATION PREDICTION STUDY

6.6.1. OBJECTIVES

The purpose of this analysis is to evaluate the vibration level to be generated by the future traffic and transport conditions along major roads such as Avenida Almirante Barroso, and find out suitable impact mitigation measures within this project. Basically, the vibration impact prediction study was carried out for the daytime and the night-time transport conditions, respectively. Here, following two vibration mitigation measures such as (i) flatness improvement of the road surface, and (ii) base course improvement, are of concern. Here, the road surface flatness and the condition of the base course are expressed in term of the standard deviation of the road surface roughness, σ (unit: mm), and the dominant vibration frequency, f (unit: Hz), respectively.

6.6.2. RESULTS AND DISCUSSIONS

In all the Without cases, it is found that both predicted L_{10} values at Bosque and Sao-Braz vary around 50 dB, below the current day-time vibration standard of Japan (65 dB). When the proposed project is implemented, predicted L_{10} values at both prediction points tend to be decreased by 3 - 4 dB. This is mainly caused by following two factors, i.e., (1) the re-configuration of vehicle lanes, increasing the physical distance between the

centerline of the outermost vehicle lane and the prediction point slightly, and (2) the improved pavement condition of the road surface. When the base course of the road structure is improved within the With case, the predicted vibration levels at both prediction points are decreased by 2 dB further. So, it can be said that significant amount of vibration reduction can be expected by implementing the proposed project as long as proper structural maintenance work is carried out. Figure 6-3 shows one of major vibration prediction results.

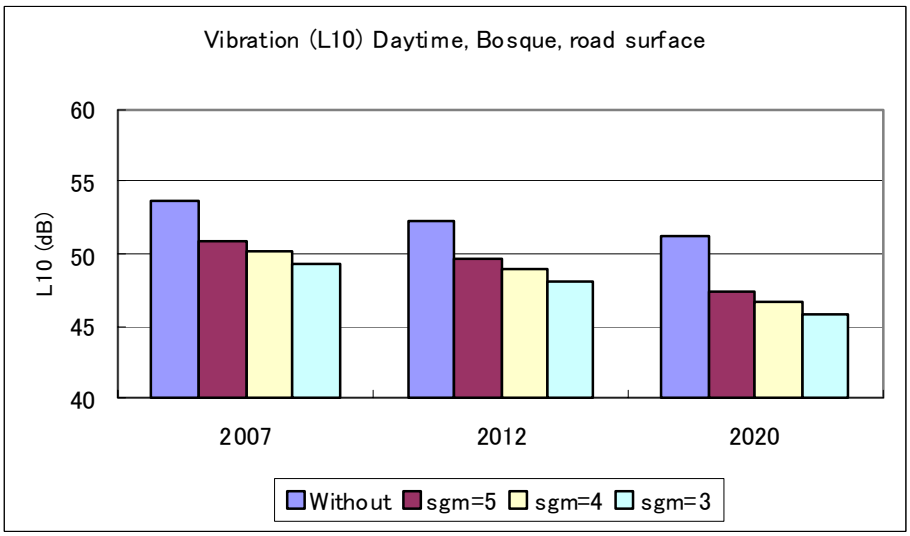


Figure 6-3 Predicted L10 value (Bosque Daytime, road surface flatness σ=3, 4, and 5 mm)

6.7. RESETTLEMENT

When resettlement or relocation issues arise within a large-scale infrastructure project, full compensation must be prepared prior to any construction activities. Followings are the estimates of lands and/or properties to be expropriated by the proposed project.

- Total number of house to be expropriated = 1,818 houses.
- Total number of house to be resettled = 601 houses.

Note: Nine Resettlement sites will be prepared by Government of Para State.
All estimates are derived, using COHAB compensation computation software.

7. IMPLEMENTATION PLAN

Table 7-1 shows the implementation program and investment by year according to working item. The implementation program for trunk busway facilities including integrated bus terminals and bus stops is planned for the period of three years from the beginning of 2004 to the end of 2006. In the beginning of 2007, the trunk bus system will be operated on Av. Almirante Barroso-BR-316 and Rodovia Augusto Montenegro, as well as on the suburban segment of Av. Independencia.

Table 7-2 shows the implementation program and investment by year according to working item. The Para State government is now constructing Av. Independencia in the suburban segment between Rodovia Augusto Montenegro and Alca Viaria. The completion of the road by the year 2006 is advisable together with widening of two lanes prepared for the trunk bus system.

In order to ensure operation of the trunk bus system on the Centro accessing segment of Av. Independencia in 2011 as mentioned above, this segment of the road with four lanes for

private vehicles and two lanes for trunk buses has to be constructed by 2011. This segment is of great importance for public transport and private traffic in the BAM.

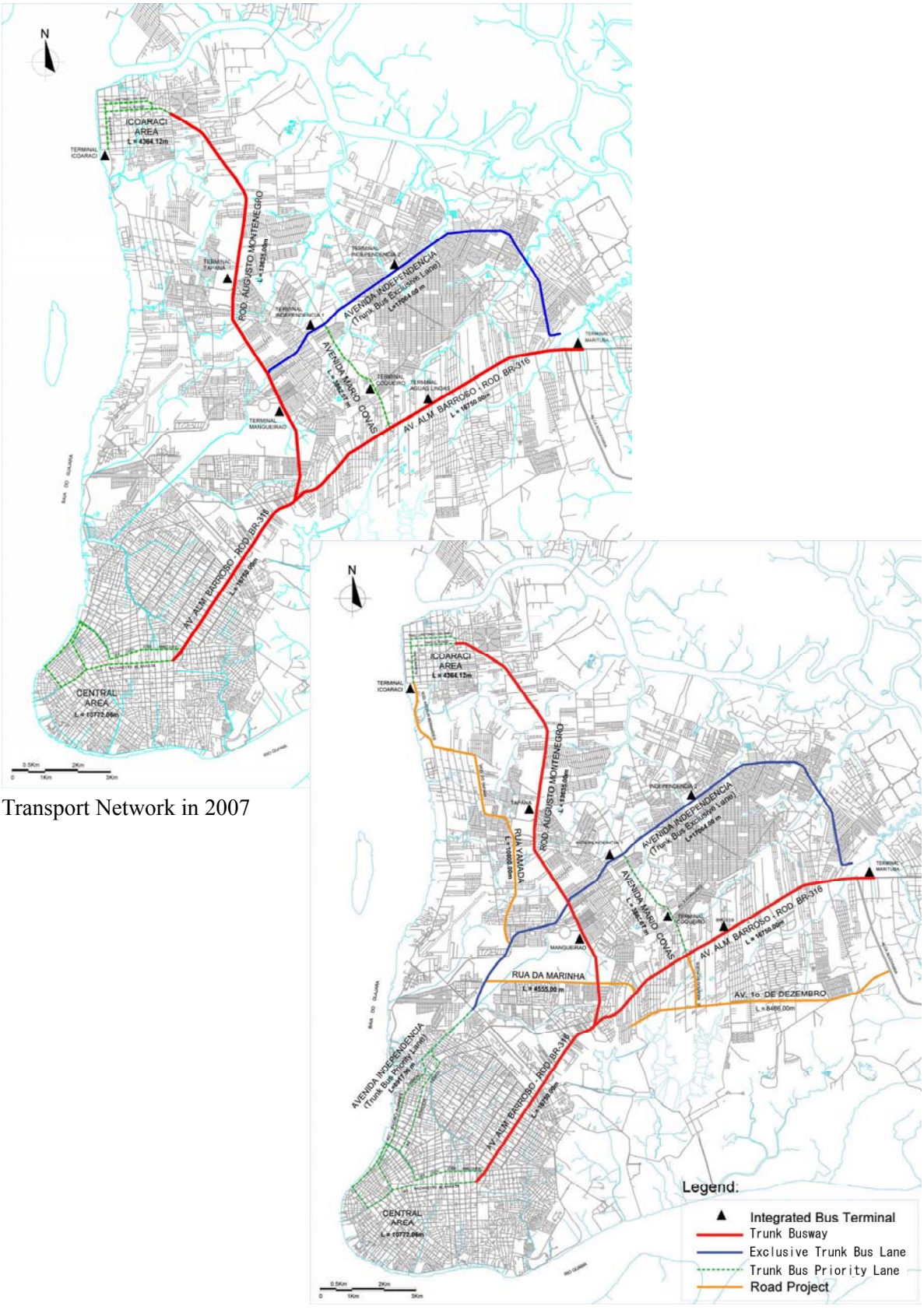
According to the implementation program, proposed road and busway networks in 2007 and 2012 are shown in Figure 7-1.

Table 7-1 Implementation Program for Trunk Bus Projects

Working Items	Classification	2002	2003	2,004	2,005	2,006	2,007	2,008	2,009	2,010	2,011	2,012
1. Completion of Feasibility Study												
2. Detailed Design (including Field Survey)												
3. Environmental Analysis												
4. Approval of Environment												
5. Preparation of Tender Document												
6. Procurement of Project Costs												
7. Tender for Construction												
8. Tender Evaluation												
9. Contract of Contractor												
10. Construction of Trunk Busway (Including related integrated bus termina	Av. Aliminante (US$1000)			3,556	3,556	10,774						
	Rod. August Monteneguro (US$1000)			6,889	6,889	20,873						
	Rod. BR-316 (US$1000)			6,449	6,449	19,541						
	Av. Independencia (US$1000)			6,280	6,280	16,021		5,612	7,743	3,856		
	Priority Lane (US$1000)			941	941	13,836						
	Bus Facilities (US$1000)			1,058	1,058	14,374						
Sum.Trunk Bus+Priority Lanes+Integrated Bus Terminals	162,976			25,173	25,173	76,335	19,084	5,612	7,743	3,856		

Table 7-2 Implementation Program for Road Projects

Working Items	Classification	2002	2003	2,004	2,005	2,006	2,007	2,008	2,009	2,010	2,011	2,012
1. Completion of Feasibility Study												
2. Detailed Design (including Field Survey)												
3. Environmental Analysis												
4. Approval of Environment												
5. Land Acquisition & Compensation												
6. Preparation of Tender Document												
7. Procurement of Project Costs												
8. Tender for Construction												
9. Tender Evaluation												
10. Contract of Contractor												
11. Construction of Roads	Av. Independencia	2,924	7,993	10,906	15,028	10,562		14,935	7,801	6,487		
	Rua Yamada				2,009	2,009	2,009			10,224	10,575	5,829
	Rua da Marinha					1,270	1,270					11,512
	Av. Primeiro de Dezembro			3,308	3,308	3,308		16,076	16,628	9,168		
Road Project excluding Av. Independencia (US$1000)	98,503			3,308	5,317	6,587	3,279	16,076	16,628	19,392	10,575	17,341
Toatl (including Av. Independencia)	338,115	2,924	7,993	39,388	45,519	93,482	22,362	36,622	32,173	29,735	10,575	17,341



Transport Network in 2007

Transport Network in 2012

Figure 7-1 Proposed Road and Busway Network in 2007 and 2012

8. ECONOMIC AND FINANCIAL EVALUATION

8.1. ECONOMIC EVALUATION

The entire project of this Study and its components were evaluated from the regional economic viewpoint, by comparing their economic cost and the economic benefit brought about by the project.

8.1.1. ECONOMIC COST AND BENEFIT

(1) Economic Cost

The financial cost stated in Section 5 was converted to the economic cost by: (a) deducting all the taxes included in the financial cost, (b) adding the appraised value of public-owned land lots for two terminals, (c) applying the shadow wage rate to unskilled labor cost and (d) deducting the price contingency. Total project cost in the economic price was R$ 785.4 million, 80% of the financial cost (Table 8-1).

Table 8-1 Financial and Economic Cost of Projects

Project	Financial Cost (R$ 1000)	Economic Cost (R$ 1000)	Econonic / Financial Rato
Trunk busway Project	424,807	337,923	0.80
Bus terminals and bus stops	47,821	38,102	0.80
Road Project	507,904	409,365	0.81
Total	980,533	785,391	0.80

(2) Economic Benefit

Economic benefit was defined as savings in the vehicle operating cost (VOC) and the travel time cost (TTC) generated by a project to be evaluated. The benefit was measured through the "with" and "without" comparison. To conduct the analysis, unit VOCs were estimated by type of vehicle as a function of travel speed. In addition, unit TTCs were estimated based on the household income statistics in 2000, at R$13.3/hour for working hours of car-owning family members and R$3.0/hour of non-car-owning family members. The resultant economic benefits are shown in Table 8-2.

Table 8-2 Economic Benefit of Entire Project

(R$ million)

Case	Cost Item	2007			2012			2020		
		Public Mode	Private Mode	Total	Public Mode	Private Mode	Total	Public Mode	Private Mode	Total
Economic Benefit	VOC	-2.8	24.1	21.3	-3.0	75.2	72.2	-0.5	10.4	9.9
	TTC	37.9	38.1	76.0	54.7	158.5	213.2	54.8	37.0	91.9
	Total	35.1	62.1	97.3	51.7	233.7	285.4	54.3	47.4	101.8

In 2007, about 20% of the benefit is generated by savings in VOC and 80% by savings in TTC. The VOC savings will expand its share in 2012 due to the opening of the trunk busway on the western section of Av. Independencia and completion of other road projects. Comparing the benefits to the public and the private mode, about one third of the benefits will accrue to the public mode and the share will fall to 18% in 2012, also due to the completion of road projects. In the long term, however, the share of the public mode will become dominant because the road projects become less effective due to the overwhelming demand increase in the future.

8.1.2. EVALUATION RESULTS

The economic viability of the project is very high showing 28.0 % of IRR and R$495 million of NPV. The B/C ratio is almost 2.0. In Brazil, the economic discount rate of 12% is generally used and then, these figures indicate the study projects are highly feasible from the economic viewpoint (Table 8-3).

If evaluating the trunk bus system project alone, the economic IRR is 17.0%, which assures the project's feasibility. However, the IRR will fall below 12% if the cost becomes 1.37 times higher than the estimate or the benefit becomes 27% lower than the estimate. Then, it is important to monitor the cost and during the period of detail design and construction and traffic volume before and after project implementation.

The IRR of the entire road project is extremely high at 41% which indicates implicitly that future traffic condition would become such worse with no road project. Another evidence of this is a small benefit in 2020, which means that the road network cannot deal with the future demand even with the study road projects.

Car traffic is forecast to grow 3.5 times by 2020, while public transport demand will increase only 1.3 times. Current capacity of the road network is absolutely insufficient to cope with such an increase of car traffic. Besides the study projects, comprehensive measures should be taken, covering not road improvement but a variety of measures such as demand management, introduction of mass-transit and decentralization of urban functions. In this sense, the trunk bus is a transitional measure to a mass-transit era and its life is possibly 15 – 20 years.

Table 8-3 Economic Evaluation Results

Project	Economic Evaluation		
	E-IRR (%)	NPV (R$ million)	B/C -
All Project	28.0	495.3	1.97
Trunk Bus System	17.0	84.9	1.36
All Road Project	41.0	429.2	2.53
Independencia	42.8	247.8	2.75
Av.Primeiro de Dezembro	45.2	330.7	5.12
Rua Yamada	18.0	37.6	1.80
Rua de Marinha	37.9	49.2	4.05

8.1.3. IMPACTS ON FUEL CONSUMPTION AND JOB CREATION

Although saving of fuel consumption is only a minor part of the entire economic benefit, it may be a key issue to car users and also important for environmental conservation. In 2012, the study projects will reduce the total daily running distance by 274,000 car-km, 2.3% of the distance in the "without" case. By this, R$23.8 million will be saved in a year. In addition, the projects will improve running speed from 15 km/hour to 16 km/hour in average. This slightly improved speed will result in a saving of R$0.7 million. Thus, a total amount of R$24.5 million of fuel cost will be saved in a year. This is equivalent to more than 100,000 barrels of gasoline.

The Belem Metropolitan area is now suffering from an unemployment problem with a 14% unemployment rate. This means about 100,000 people are looking for a job. Under such a situation, the study projects are significant also in job creation in the course of implementation. Total project cost is R$747 million, 7 to 8 % of which is envisaged as personnel cost. This amount corresponds to the wage payment to 62,300 man-months, of which 27900 man-months are for the unskilled. Thus, the Study projects will expectedly contribute to mitigation of the unemployment issue.

8.2. FINANCIAL ANALYSIS

8.2.1. VIEWPOINT OF ANALYSIS

The objective of this financial analysis is to examine the profitability of the trunk bus business in Belem. The scope of the business is defined as (1) trunk bus operation, (2) feeder bus operation and (3) terminal operation directly related to the trunk bus operation. Infrastructure for the trunk bus system shall be developed by public investment and bus operators do not need to bear the cost.

8.2.2. DEMAND AND FARE INCOME

The number of passengers of the trunk bus system will increase significantly from 2007 to 2012 due to the new trunk bus route along Av. Independencia and after 2012, a slight increase at 0.8 – 1.0% p.a. will continue (Table 8-4).

Currently, about 23% of bus passengers are free riders and 36% pay a 50% discount fare. Accordingly. About 60% of total passengers are the paying passengers equivalent. The fare revenue is estimated at R$550 million in 2012 and the amount will increase at the same rate as the passenger increase rate stated above.

Table 8-4 Daily Passenger and Annual Revenue of Trunk Bus and Feeder Bus

Kind of Bus	Passengers (1000pax/day)			Annual Revenue (R$ million)		
	2007	2012	2020	2007	2012	2020
Trunk Bus	638.9	958.9	1028.0	115.0	171.8	183.6
Feeder Bus	376.4	532.3	591.5	395.3	379.1	391.1
Total	1015.3	1491.2	1619.5	510.3	550.8	574.7

8.2.3. BUS FLEET PROCUREMENT PLAN

The existing bus fleet of 300 units is used for the trunk bus system and 50 units for feeder bus service. These used buses will be replaced after 10 years usage, with new articulated buses. The appraised value of these buses is R$21.8 million. New buses will be purchased with the cumulative retained profit or a loan. Therefore, the used buses are only initial investment to this project done by the operator. Then, the appraised value is regarded as the capital in kind, paid up in 2006.

The bus procurement plan shown in Table 8-5 assumed bus purchase every three years in advance. As an articulated bus costs R$470,000 and a standard bus costs R$125,790 at 2003 price, total cost in 2007 – 2026 will amount to R$247.0 million (R$ 226.5 million for articulated buses and R$20.5 million for feeder buses). This total amount corresponds to the fare revenue of 1.4 years.

Table 8-5 Schedule and Cost of Bus Procurement

(Bus unit; R$ million)

Year	Bus to be Procured		Fleet Cost		
	Articulated	Standard	Articulated	Standard	Total
2007	63	21	29.6	1.8	31.5
2010	113	36	53.1	3.2	56.3
2013	50	18	23.5	1.6	25.1
2016	61	23	28.7	2.0	30.7
2019	122	39	57.3	3.4	60.8
2022	54	19	25.4	1.7	27.1
2025	19	7	8.9	0.6	9.5
Total	482	163	226.5	14.3	240.9

8.2.4. BUS OPERATING COST

The CTBel (Belem Transport Company) updates the operating cost of a large bus every year as a basic data for bus fare revision. According to the data, the operating cost was R$2.09 per km in 2001, including tax. The variable cost accounted for 35% of the total, the fixed cost for 55.6% and tax for 9.7%.

Table 8-6 Annual Operating Cost of Trunk Bus System

(R$ million)

Year	Operating Distance (million veh.-km)		Operating Cost (R$ million at 2003 price)			
	Trunk Bus	Feeder Bus	Management*	Trunk Bus	Feeder Bus	Total
2007	15.90	6.70	2.8	62.5	26.3	91.6
2011	23.35	9.36	2.8	91.8	36.8	131.3
2012	24.16	9.85	2.8	94.9	38.7	136.5
2020	25.64	11.08	2.8	100.7	43.5	147.1

Note: Management cost is operating cost of TBSMU

8.2.5. CASH FLOW AND FINANCIAL IRR

Cash flow of the project was evaluated from two points of view: one is the net cash flow of the project as a whole, and the other is the cash flow from the viewpoint of the investors (or equity holders). Each cash flow is defined as follows (see Figure 8-1):

a) Project Cash Flow = Net Income before depreciation - Investment

b) Equity Cash Flow = Cash in Hand (Free Cash) - Equity Investment

The net operating income from 2007 to 2027 is R$665.1 million and the average fare-box ratio (revenue/ operating expense) is 1.23, which suggests a moderate profitability of the project. During the period of 2008 – 2011, the net income after tax will be negative but the absolute amounts are less than depreciation amount and then the cumulative cash flow can keep positive (see Figure 8-2).

In the first decade, the debt ratio will be rather high in the rage of 40 – 70% but it will be gradually improved down to 10 – 30% in the next ten years. Then, borrowing a loan for fleet acquisition is one of the key issues of this project.

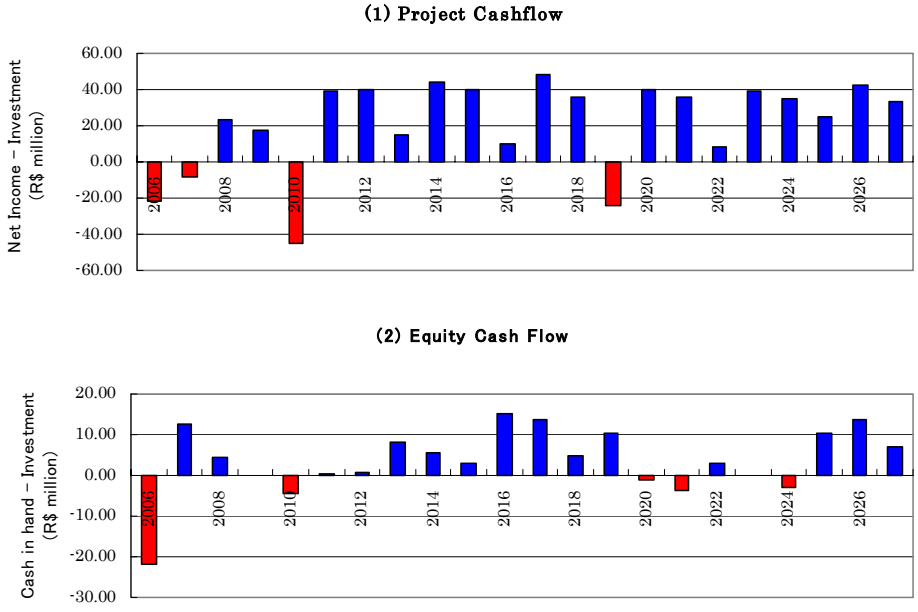


Figure 8-1 Project and Equity Cash Flows of Trunk Bus Project

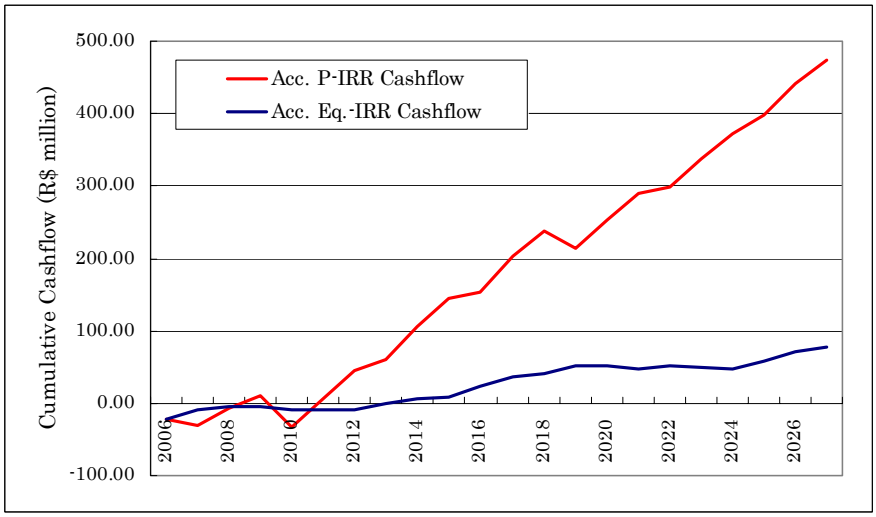


Figure 8-2 Cumulative Cash Flows of Trunk Bus Project

The project IRR is very high at 40.9% and Equity IRR is 20.3%, which is generally on a satisfactory level. Especially in case of the equity IRR, however, the initial investment amount is comparatively small and then the NPV is a small amount of R$6.6 million, even with such a high F-IRR (Table 8-7). The equity IRR is rather sensitive to the income and the cost factors, then careful monitoring and proper fare revision will be needed through the operation period.

Table 8-7 Financial IRRs and their Sensitivity

Factor to Change	Conditions	Project Evaluation		Shareholder's Evaluation	
		Project IRR	NPV	Equity IRR	NPV
		%	R$ million	%	R$ million
Base Case	-	40.9	82.2	20.3	6.6
Revenue	5% UP	43.7	90.7	24.9	12.8
	5% down	38.1	73.7	15.4	0.4
	10% down	35.4	65.2	9.7	-5.7
Price of Bus	10% down	45.2	91.2	25.0	13.1
	10% up	36.9	73.2	15.2	0.2
	20% up	33.3	64.2	9.3	-6.3
Tax	10% down	-	-	25.7	14.0
	10% up	-	-	17.4	7.9
	20% up	-	-	14.4	-0.7
Interest Rate	15% - 2.5%	-	-	23.0	10.2
	15% + 2.5%	-	-	17.5	3.1
	15% + 5.0%	-	-	14.6	-0.5

Under a fixed interest rate and scheduled repayment, a cash flow is favorably affected by inflation because every item of revenue and cost is escalated by inflation and the amount of principal repayment and interest becomes relatively less. If assuming annual inflation rate at 11%, the cash flows are much improved and the nominal project IRR is 50.6% and the nominal equity IRR is 37.3%.

It is concluded the trunk bus project is financially viable under the assumed conditions. After paying interest and taxes, however, the retained profit will not be enough to increase and replace bus fleet. So it may be necessary to look for a soft loan with a favorable terms unless taxes are exempted.

9. RECOMMENDATIONS

9.1. NECESSITY OF THE PROJECTS

The PDTU2001 was conducted by joint efforts of the Brazilian and the Japanese study team over a period of one year from 2000 to 2001, and the various projects were recommended to improve the traffic congestion and maintain sound activities in BMA. Following the PDTU2001, the Feasibility Study on the Improvement of Transport System in the Metropolitan Area of Belem, which were recommended by the PDTU2001 as the high priority projects as well as the urgent implementation projects, were conducted. As the implementation of projects recommended under the Study will contribute to the followings, it is necessary to implement these projects as soon as possible:

1) To mitigate and to reduce traffic congestion;
2) To contribute in setting up to maintain the trunk bus system, and to ensure efficiency of bus operation system;
3) To contribute to the social and natural environment by reducing air pollution; and
4) To increase economic and social activities.

9.2. TRUNK BUS SYSTEM PROJECT

(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 present study proposes the following infrastructural development.

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 Avenida 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.
7) Existing Sao Braz Bus Terminal, currently serving long-distance buses, is converted to the intra-city transfer bus stop facility between the trunk and the conventional bus service.
8) Trunk bus traffic signals are installed at every major intersection along the trunk busways, exclusive trunk bus lanes and trunk bus priority lanes.
9) The trunk bus priority lanes are replaced from the asphalt concrete pavement to cement concrete pavement at major intersections inside Belem Central Area.

Table 5-2 shows the recommended trunk bus projects.

9.3. 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.

The route of Av. Independencia is planed to skirt around the Parque Presidente Medici (natural conservative park) because the original route passes through the park. In the plan of Primeiro de Dezembro, the household waste water from the northern residential areas from seeping into the reservoir is partly checked to protect the natural environment around the reservoir on the south. Rua da Marinha runs next to the nature conservation area (Parque Presidente Medici). Therefore, to take environmental precaution in the road structure, an elevated road instead of ordinary embankment is proposed to allow free mobility of small wild animals.

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 5-3 shows the recommended road projects.

9.4. PROJECT COST AND FINANCIAL RESOURCE

The total investment of the trunk bus and road projects as shown in Table 5-2 and Table 5-3 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. 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.

9.5. FURTHER STUDIES

The Government of Para State is to officially implement the 4-year Metropolitan Integration Program (2004 - 2007) after the Council of Para State will approve this program. This four-year program includes the trunk bus system and road projects proposed in this feasibility study. The on-going project of Avenida Independencia planned and supervised by the Para State, which will be very important component for the proposed trunk bus system, is also to be approved and be integrated formally in this program.

In order to proceed the proposed project in this 4-year program further, several works must be done at the next project stage. Among of them, the priority of the detailed design of following project components such as,

1) Trunk busway on Rodovia BR-316, Avenida Almirante Barroso and Rodovia Augusto Montenegro
2) Exclusive trunk bus lanes on Avenida Independencia
3) Trunk bus priority along a number of roads within Belem and Icoaraci Cities and Avenida Mario Covas in Cidade Nova
4) Integrated bus terminals and Bus stop facilities

is quite high and those tasks shall be initiated immediately after the completion of the feasibility study of this proposed project.

To proceed those tasks and keep the momentum developed since PDTU1991, further interaction and cooperation between Brazilian and Japanese sides must be required, and there are several areas that the Japanese side can make technical assistance for the Brazilian side as did in this feasibility study. Among of them, the area of the future traffic demand analysis in Brazil is still at the rudimentary stage and need more time, experiences and human resources to develop further. So, it is strongly recommended to dispatch the technical adviser of the trunk bus system, in particular, traffic demand analyst as well as other relevant area for the deep-understanding of this project.

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Note: * Predecessor

List of Abbreviations

AGR:	Goiania Agency of Regulation, Control and Supervising of Public Services
AMPPPC:	Municipality Agency of Preservation and Protection
ABNT:	Brazilian Association of Technical Rules
APA:	Environmental Protected Reserves
APEG:	Ecological Research Area of GUAMA
ARCON:	State Agency of Regulation and Control of Public Services
BMA:	Belem Metropolitan Area
CDTC:	Deliberative Chamber of Public Transports of Goiania
CMTC:	Metropolitan Company of Public Transport
COHAB:	Para State Habitation Company
CONAMA:	National Concierge of Environmental
CONAMAZ:	National Council of the Amazon Region
CONERC:	Council State of Regulation and Public Services Control
CONSEMA:	Council State of Environment
CONTRAN:	National Transit Council
COSANPA:	Para State Sanitation Company
CTBel:	Transport Company of Belem Municipality
DEMUTRAN:	Municipality Department of Transports and Traffic
DPHAC:	Department of Historical, Architectural and Cultural Heritage Conservation
DETRAN:	State of Para Department of Transit
DNIT:	National Department of Road Transport Infrastrutucture
IEE:	Initial Environmental Examination
EBTU:	Urban Transports Brazilian Enterprise
EIA:	Environmental Impact Study
EMTU:	Urban Transports Metropolitan Municipality
FADESP:	Foundation of Support and Develop for the Research
FUMBEL:	Belem Cultural Heritage Foundation
FUNVERDE:	Belem Green Area and Park Foundation
GETRANS:	Executive Group of Management of Metropolitan Network of Public Transports
GETRAT:	Special Study Group for Decreasing
IBAMA:	Brazilian Institute of Environmental and Renewalbe natural Resources
IPHAN:	National Institute of Historical/Architectural and Cultural Heritage
IPPUC:	Institute of Urban Survey and Planning of Curitiba
JICA:	Japan International Cooperation Agency
LI:	License for Installation
LO:	License for Operation
LP:	Preliminary License
OD:	Origin and Destination
PDTU:	Master Plan Study on Urban Transport in Belem
PEA:	Environmental Egineering Desing Report
PROCONVE:	Brazilian Program of Pollution Control
PROSANEAR:	Sanitation Program for Low-income People
RCA:	Environmental Control Report
RMG:	Goiania Metropolitan Area
SAAEBE:	Belem Water and Siwerage Autonomous Service
SECTAM:	Executive Secretariat of Science, Techonology and Environmental
SECULT:	Executive Secretariat of Culture

SEGUP:	Executive Secretariat of Public Security
SESMA:	Secretariat of Health and Environment of Belem Municipality
SETRAN:	Executive Secretariat of Transports
SETRANSBEL:	Syndicate of Transport Companies of Belem
SISNAMA:	National System of Environment
SISP:	Integrated System of Public Security
SMT:	Municipality Secretary of Transport and Circulation
TELEMAR:	Tele North East Participations S.A
UFPA:	Federal University of Para
URBS:	Transport Company of Curitiba