

PART C

PLANNING OF ROAD PROJECTS

CHAPTER 12  
Existing Road Conditions

## ***PART-C PLANNING OF ROAD PROJECTS***

### **12. EXISTING ROAD CONDITIONS**

#### **12.1. EXISTING ROAD CONDITIONS**

##### **12.1.1. ROAD NETWORK CONFIGURATION AND NUMBER OF LANES**

As shown in Figure 12.1-1 and Figure 12.1-2, the road network in the study area has two distinct patterns that reflect the different levels of land use in the central part of Belem and the suburbs. The network in the built-up area of Belem is basically a gridiron layout. Outlying areas are characterized by radial roads extending from the center of Belem. These roads connecting suburban agglomerations to Centro are designated as two-way arterial roads with six or eight lanes.

##### **(1) Central Area (Centro)**

The central area corresponds to Primeira Legua Patrimonial, which was initially formed around the year 1900 with the gridiron layout of streets. The streets of Centro have two or four lanes, with closely packed roadside buildings used for residence and business. Many of these streets are for one-way traffic (see Figure 12.1-1).

##### **(2) Suburban Areas**

The road network in the suburbs is formed radially from the center of Belem, but each of the three suburban agglomerations is connected by a single arterial road to Centro. This is the bottleneck of the suburban road network. The roads connecting Centro to the suburbs have three major axes, as shown below (see Figure 12.1-2).

- 1) Centro – Icoaraci (North-south traffic axis)  
Centro – Av. Almirante – Rodovia Augusto Montenegro – Icoaraci
- 2) Centro – Cidade Nova (East-west traffic axis)  
Centro – Av. Almirante – Rodovia BR-316 – Cidade Nova
- 3) Centro - Marituba (East-west traffic axis)  
Centro – Av. Almirante – Rodovia BR-316 – Marituba

Av. Pedro Alvares Cabral and Av. Almirante Barroso are two links to connect Centro toward the suburbs, but they merge at the intersection of Entroncamento near the municipal border between Belem and Ananindeua. From the same intersection, Rodovia Augusto Montenegro extends toward Icoaraci, while Rodovia BR-316 goes to Ananindeua. New residential development activities of Belem Metropolitan Area (BMA) have been chiefly concentrated in the area north of Rodovia Augusto Montenegro and BR-316. Given the concentration of commercial and service establishments in Belem Centro, the continuing growth of suburban residential areas necessarily increases the traffic between Centro and the suburbs.

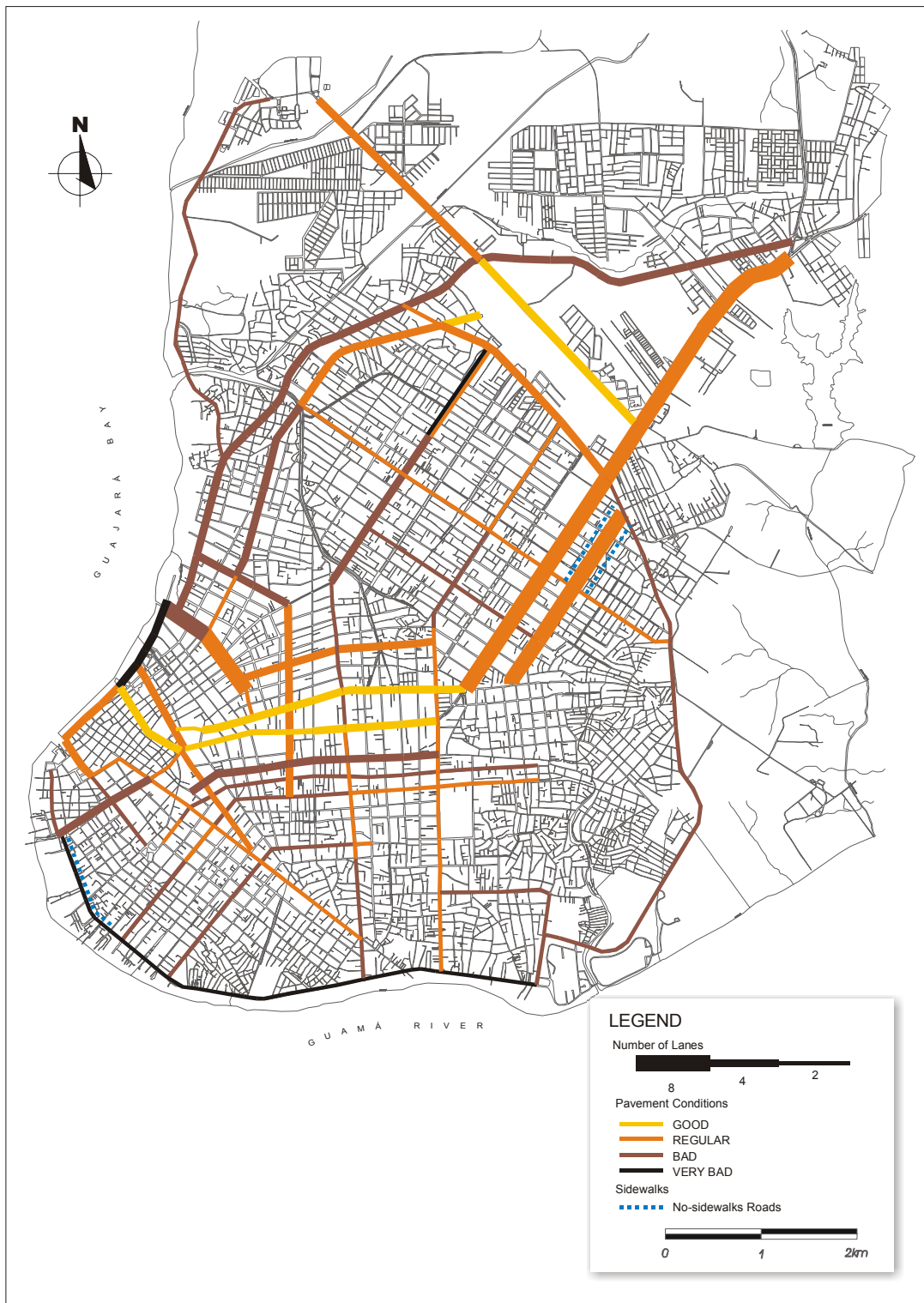


Figure 12.1-1 Road Network in Belem Centro by Number of Lanes

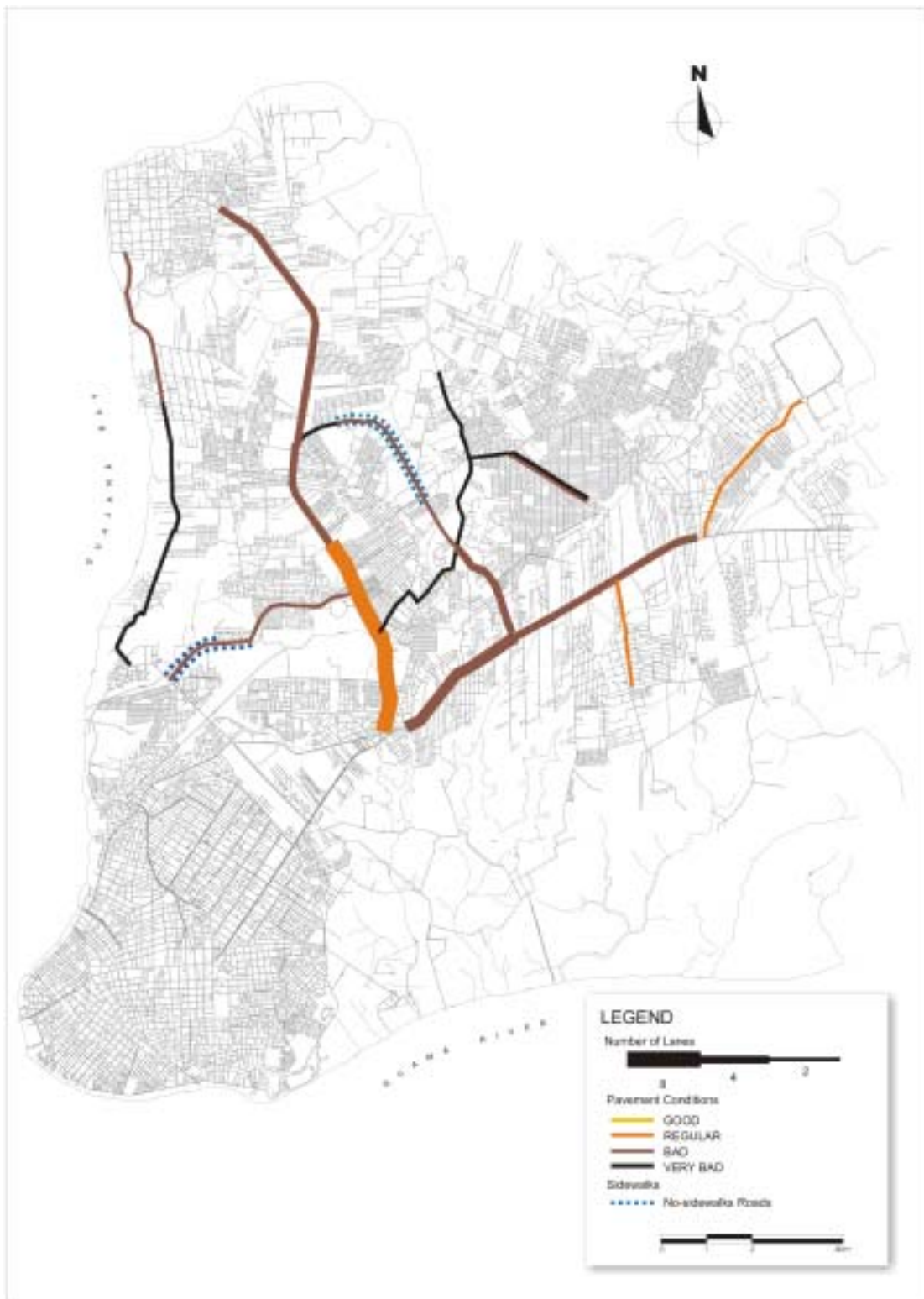


Figure 12.1-2 Suburban Road Network by Number of Lanes

### 12.1.2. EXISTING MAJOR ROADS

The following is the description of four major arterial roads in the study area.

#### (1) Av. Almirante Barroso

This avenue, the most important link between Centro and the suburbs, runs 6km from the very center of Centro to the municipal border, and connects to Rodovia Augusto Montenegro and BR-316 at the intersection of Entroncamento. The avenue has eight lanes, comprising four-lane two-way through roadway and two-lane frontage road on both sides. As shown in the cross section in Figure 12.1-3, the avenue has the median in the center, part of which is now being converted to exclusive bikeway. Traffic signals are spaced three at every kilometer in Centro and one at every kilometer in the transition area. The signal cycle length gives precedence to this avenue, with a green time ratio of 70% per cycle length.

Major traffic characteristics of Av. Almirante Barroso are shown in Table 12.1-1 in which the traffic volume was counted in 2002 in the study. The inbound peak-hour traffic adds up to 4,300 vehicles, of which 613 are buses and minibuses. The percentage of buses in the inbound peak-hour traffic is considered very large, probably nearing the upper limit. The peak ratio is relatively low at 9.9%, indicating the urban characteristic that the traffic volume does not differ very much between peak and off-peak hours. The ratio of inbound traffic in the total peak-hour traffic is not lop-sided at around 60%, also indicating the urban characteristic. The other three major arterial roads in the table show similar characteristics.

Table 12.1-1 Traffic Characteristics on Four Major Arterial Roads in 2002

	Av. Almirante Barroso		Rodovia BR-316		Rod. Augusto Montenegro		Av. Pedro Alvares Cabral	
Ratio of daytime traffic (ADT)	1.38		1.33		1.35		1.36	
Peak hour	7:00 – 8:00		7:00 – 8:00		7:00 – 8:00		7:00 – 8:00	
Percentage of peak-hour traffic in ADT (peak ratio) (%)	9.9		6.5		9.4		10.6	
Ratio of inbound traffic in total peak-hour traffic	0.58		0.50		0.66		0.75	
Inbound peak-hour traffic:	Volume	Ratio	Volume	Ratio	Volume	Ratio	Volume	Ratio
Passenger car	3397	0.79	1122	0.64	1480	0.75	2194	0.87
Bus and Microbus	613	0.14	219	0.13	285	0.14	161	0.06
Truck/ Others	280	0.07	411	0.23	208	0.11	160	0.06
Total	4290	1.00	1752	1.00	1973	1.00	2515	1.00

#### (2) Rodovia BR-316

This road is the only national road in the study area and connects Belem to Brasilia. It originates in Entroncamento where it is directly linked to Av. Almirante Barroso. As shown in Figure 12.1-4, the road has six lanes with the median in the segment near Entroncamento and four lanes in the outlying segment.

Major traffic characteristics of BR-316 are shown in Table 12.1-1. Of the total inbound peak-hour traffic of 1,800 vehicles, 219 are buses and minibuses, smaller by about 400

than Av. Almirante Barroso. The ratio of inbound traffic in total peak-hour traffic is 0.5, slightly lower than the other arterial roads, because BR-316 accommodates more intra-suburban traffic.

**(3) Rodovia Augusto Montenegro**

The avenue is a municipal road and runs from Icoaraci to Entroncamento where it directly connects to Av. Almirante Barroso. As shown in Figure 12.1-5, it has the median with bikeway of 1.5m on each side. The road segment near Entroncamento has six lanes, which decreases to four lanes toward Icoaraci.

Major traffic characteristics are shown in Table 12.1-1. The inbound peak-hour traffic totals about 2,000 vehicles, of which 290 are buses and microbuses. The percentage of buses in the inbound peak-hour traffic is considered very large. The avenue undoubtedly has a very important role to play in public transportation.

**(4) Av. Pedro Alvares Cabral**

The avenue originates at the Entroncamento intersection of Rodovia Augusto Montenegro and BR-316, and approaches Centro from the north after diagonally crossing the transition area. It has six lanes. The avenue is one of the two roads that connect Belem Centro to the suburbs. Av. Almirante Barroso, the other of the two, provides the major arterial road link to the suburbs, while Av. Pedro Alvares Cabral serves as the complementary arterial road link.

Major traffic characteristics are shown in Table 12.1-1. The inbound peak-hour traffic totals about 2,500 vehicles, of which 160 are buses and microbuses. The volume of bus traffic is noticeably smaller than the other arterial roads, indicating the role of the avenue as a secondary alternative to Av. Almirante Barroso.

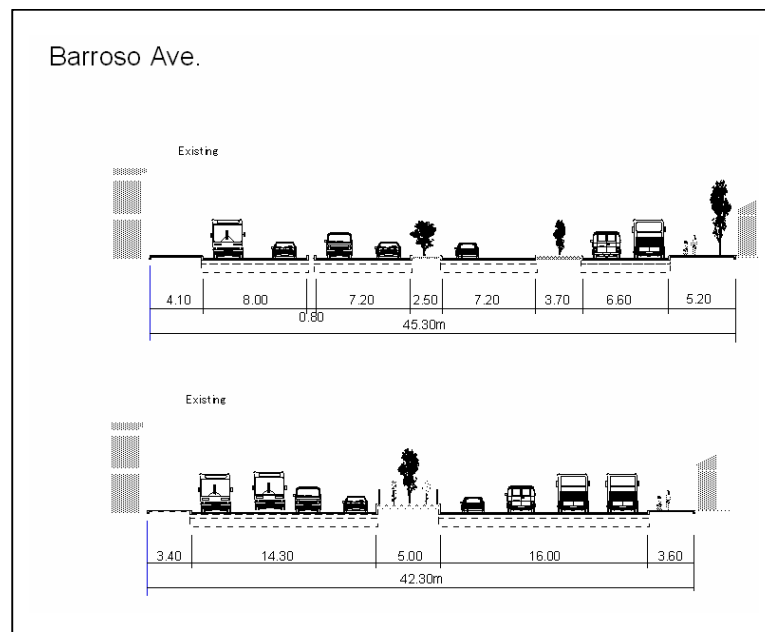


Figure 12.1-3 Typical Cross Sections of Almirante Barroso

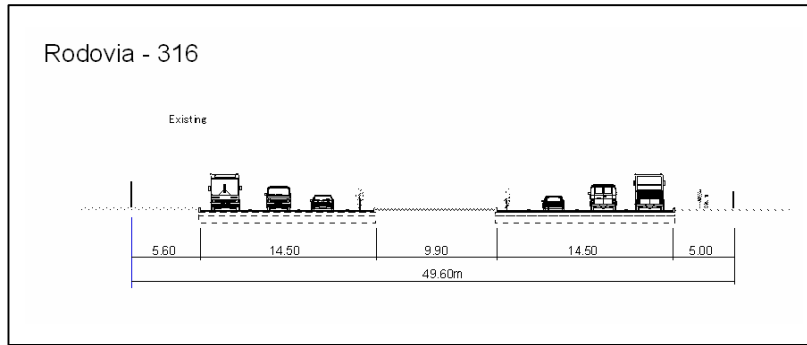


Figure 12.1-4 Typical Cross Sections of BR-316

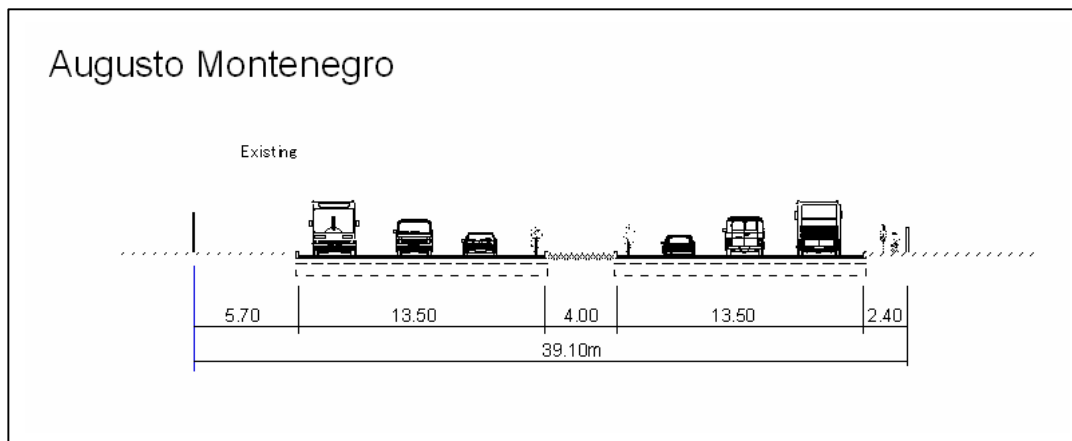


Figure 12.1-5 Typical Cross Sections of Rodovia Augusto Montenegro

### 12.1.3. ROAD FACILITY CONDITIONS OF MAJOR ROADS

#### (1) Cross Section Elements

Many major arterial roads have six cross section elements: namely, (i) median, (ii) bikeway, (iii) roadway, (iv) shoulder, (v) sidewalk, and (vi) drainage. The median width varies from 3 to 10m per road segment, and they are normally planted with trees of 10 to 15cm diameter.

The bikeway is provided along the median on some roads and on the shoulder between the roadway and the sidewalk on other roads. The roadway and the bikeway are separated by marking or cats' eyes, but the coexistence of fast motorized traffic and slow cycling on the same road level is extremely hazardous. The bikeway width is not uniform, varying from 1.5 to 1.8m.

The lane width is from 3.0 to 3.5m, but reduced to less than 3.0m around intersections and on the segments where the bikeway has been added later on. Lane marking on the multi-lane roads is poorly maintained and hardly visible.

#### (2) Pavement

All major arterial roads in the study area are paved with asphalt. According to PDTU2001, the pavement condition is bad on 55.0% of the arterial roads. Within Centro, the condition is good on 45.0% of the arterial roads. The said study has found no pavement in excellent condition in the study area. The pavement condition of Centro is relatively adequate in



maintenance, but the arterial road segments in the suburbs are poorly maintained with portions of the pavement gone in many places.

### **(3) Drainage**

The terrains in the study area are on the whole flat with the highest altitude of 27m. Tropical heavy rainfalls run off in numerous streams and rivulets, and the canals have been dug in the lowlands to the north of Centro. These natural streams and the canals serve to drain storm water from the urban built-up areas. The existing major arterial roads were constructed along watersheds and are usually well drained, although heavy rains occasionally cause temporary inundation in some places. Drain ditches are buried along the road shoulder, sidewalk or median to catch storm water.

### **(4) Intersections**

Most of the intersections are grade crossing. Grade-separated intersections and roundabouts are few. The grade-separated intersection of Av. Almirante Barroso and Av. Perimetral has been recently completed by the financing of BID (Inter-American Development Bank). Another grade separation is under construction at Entroncamento, the intersection of Av. Almirante Barroso and Rodovia Augusto Montenegro.

### **(5) Flood Control**

Storm drainage basically depends on natural streams, and there has been no planning to secure sufficient drainage capacity. Consequently, some areas are left to serve as natural retarding basins during heavy rains. The Guajara and the Guama near Belem City are tidal rivers, and the canals have entrance locks against high tide.

### **(6) Related Road Facilities**

#### **1) Pedestrian bridges**

Pedestrian bridges are provided near schools and public facilities. However, pedestrians rarely use these bridges to cross arterial roads, including six-lane roads. The standard height of the bridges is set at 5m.

#### **2) Bikeway**

There is neither bikeway nor bike lane on the streets in Centro. Four-lane arterial roads that connect Centro to the suburbs have bikeways. The location of bikeway network is shown in Figure 12.1-7.

The two-way bikeway is provided by banking up the median by about 50cm in certain segments of Av. Almirante Barroso as shown in Figure 12.1-6. The level separation from motorized traffic ensures the safety of cyclists. Cyclists use intersections to cross from the median to the sidewalk.

Regarding Rodovia Augusto Montenegro and BR-316, the bikeway is provided to flank the median on both sides (1.5m in width one way) on the same level as the roadway for motorized traffic. The separation of the bikeway from the roadway is done by marking or cat's eyes without any space in between, suggesting serious safety hazards for cyclists.

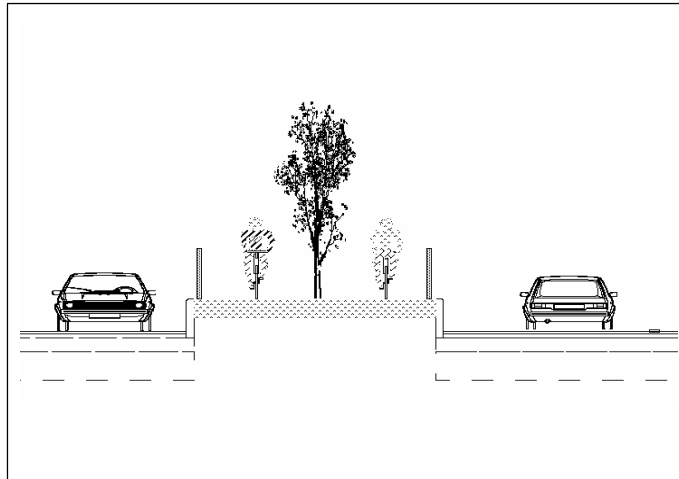


Figure 12.1-6 Bikeway on Av. Almirante Barroso

### 3) *U-turn lanes*

To avoid U-turns at intersections, lanes are provided to cross the median some 100m before intersections on major arterial roads such as Av. Almirante Barroso, Rodovia BR-316 and Rodovia Augusto Montenegro. The width of U-turn lanes is mostly 2.5m.

### 4) *Bus bays*

Bus bays are rarely provided at bus stops within Centro. Many bus stops have bays on arterial roads connecting Centro to the suburbs. However, the capacity of these bays is not enough to accommodate many buses that come in rapid succession during peak hours. Because of the imbalance between the available bay space and the demand, many buses have to stop at the nearby curb to pick up passengers. This oft-observed practice reduces the road capacity and is one of the causes of traffic congestion.

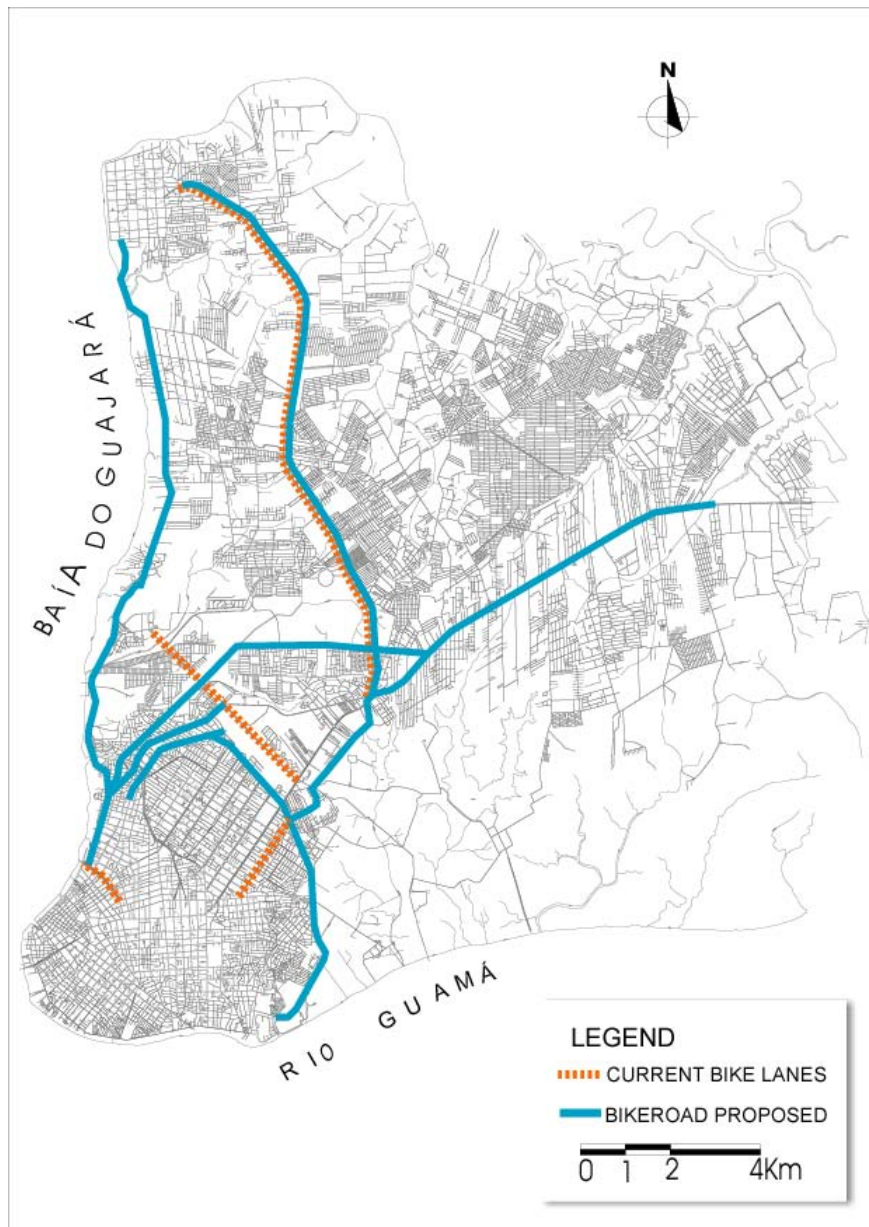


Figure 12.1-7 Location of Bikeway

## 12.2. ROAD ADMINISTRATION AND ORGANIZATION

### 12.2.1. ROAD ADMINISTRATION

In terms of administrative responsibility, roads are classified into federal, state and municipal roads. Federal roads are constructed, operated and maintained by DNER, state roads by Executive Secretary of Transports (SETRAN) and municipal roads by SRM. These administrative bodies contract and supervise private companies to construct and maintain the roads under their responsibility. There are five designations of roads in BMA as Rodovia, Avenida, Rua, Transversa and Passagem, however, a hierarchy of road functions is not clearly defined. Av. Almirante Barroso, BR-316 and Rodovia Augusto Montenegro are functioning as *de facto* major arterial roads, while Av. Pedro Alvares Cabral serves as an arterial road. PDTU2001 has made the functional classification of existing roads to prepare and propose its road plan.

### 12.2.2. ORGANIZATION

SEIR is responsible for planning, construction, operation and maintenance of the entire infrastructure in Para State, and controls eight statutory bodies that execute project planning, construction, operation and maintenance in eight infrastructural subsectors. SETRAN is one of the statutory bodies responsible for transportation, and has three bureaus respectively in charge of land transport, water transport and airports. The headquarters of the Land Transport Bureau has two sections respectively in charge of road infrastructure and road operation, which supervise a number of local offices. The road infrastructure section is divided into the construction and the maintenance units. The construction unit is further divided into two subunits in charge of construction in general and special construction, while the maintenance unit comprises the mechanical and the maintenance subunits. The road operation section has the technical and the operation units.

The Road Department of the Federal Ministry of Transportation is responsible for federal roads. Regional Offices (DNITs) of the Department are in charge of planning, operation and maintenance on the state level.

Planning, construction and maintenance of municipal roads are undertaken by the municipal road maintenance bureau in Belem and by the municipal infrastructure bureau in Ananindeua City.

## 12.3. EXISTING PROBLEMS AND ISSUES

### 12.3.1. ROAD NETWORK

Road network density is relatively high and the one-way traffic regulation is in force in Centro. 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.

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.

Upgrading and improvement of the existing radial roads are urgently needed to alleviate traffic congestion and strengthen the linkage between Centro and the suburbs. 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

### 12.3.2. ROAD FUNCTIONS

As mentioned earlier, the lack of clear functional differentiation of roads has allowed all kinds of trips to converge on major suburban arterial roads, and is now worsening traffic

congestion. The peak-hour traffic on Av. Almirante Barroso contains as many as 525 buses/h and the flow of traffic on the frontage road is frequently slowed down by a succession of buses picking up passengers at roadside bus stops. The frontage road looks like a *de facto* exclusive bus lane during peak hours. Added to this, buses overtake one another around bus stops, clogging and delaying the traffic flow as a whole. It will be necessary to separate public transport and private vehicles, and thereby to enhance the convenience of bus transport. This will ultimately serve to realize more efficient traffic management in the study area.

### **12.3.3. ROAD FACILITIES**

#### **(1) Grade-separated Intersections**

U-turn lanes are provided on arterial roads to reduce left turns at intersections. However, this provision itself is likely to become a bottleneck, when the motorized traffic continues to grow to the level where U-turn lanes cannot handle adequately. It will be necessary to consider the prospect of introducing grade separation at the intersections of two arterial roads.

#### **(2) Sidewalk**

Streets of Centro are flanked on both sides by the sidewalk of 3.0 to 5.0m. Mango trees are planted on the sidewalk, and some of them are as old as 100 years or even older. The suburban arterial roads pass along factories, residential areas and commercial centers where there are many pedestrians. However, there is no clear separation between the road shoulder and the sidewalk, and trees are rarely planted on the sidewalk. Partly to improve the pedestrian amenity and partly to improve the roadside landscape, it will be necessary to consider the provision of the sidewalk (minimum width of 1.5m) and the tree belt (1.0m) on the suburban arterial roads.

#### **(3) Bikeway**

Arterial roads have the bikeway or the bike lane of 1.0 to 1.5m in width either on or next to the median. On Av. Almirante Barroso, the traffic on the bikeway includes many delivery service bicycles as well as cycling commuters. The municipalities in the study area are eager to extend the bikeway network, and Belem City has been implementing its bikeway extension plan. PDTU2001 also recommends the bikeway on many arterial roads. The present Feasibility Study finds it necessary to examine the issue of establishing the bikeway either on the roadside or the median.

#### **(4) Bus Stops**

Bus stops as public transportation facilities are established on the shoulder of arterial roads. Bus bays are provided at many stops, but their design capacity is inadequate to meet the demand of the current bus traffic. The present Feasibility Study thinks it necessary to examine the appropriate location and design requirements of bus stops by analyzing the findings of passenger surveys on public transport.

#### **(5) Pedestrian Bridges**

Pedestrian bridges were constructed close to the bus stops that service such public facilities as schools and hospitals nearby. The design height is 5m on most arterial roads. The present Feasibility Study examines the appropriate location of pedestrian bridges in conjunction with bus stops.

**(6) Drainage**

The arterial roads in the study area were generally constructed on flat terrains. Some intersections are found flooded during the rain due to inadequate drainage. Surface drainage facilities are usually designed by the ten-year probability, but the inadequate maintenance has reduced the draining capacity in many places. The present Feasibility Study finds it necessary to examine the appropriate scale of road drainage facilities such as cross and long drain pipes.

**(7) Electricity**

Av. Independencia and some other roads utilize the ground level of electric transmission lines. It is necessary to plan the road widening and grade separation by securing the clearance from power cables and cable towers.

CHAPTER 13  
Planning Conditions Of Road Projects

## **13. PLANNING CONDITIONS OF ROAD PROJECTS**

### **13.1. GENERAL CONDITIONS OF ROAD PLANNING**

#### **13.1.1. OUTLINE OF PDTU2001**

##### **(1) General**

The Master Plan Study on Urban Transport in Belem (hereinafter referred to as PDTU1991) was carried out by JICA in 1991, but the subsequent economic downturns in Brazil made it difficult to implement the recommended projects therein, except for the Av. Independencia and the Primeiro de Dezembro projects. In the mean time, the number of car ownerships increased rapidly apace with the residential development in the suburbs of Belem City. The number of registered cars in 2000 was already close to the forecast made in 1991 for the year 2010. Increased traffic congestion in the city has become a serious social hazard, by lengthening the commuting time and worsening environmental conditions. In view of these changes, JICA organized in 2001 another study, entitled the Update of the Master Plan for Urban Transport in the Metropolitan Area of Belem (hereinafter referred to as PDTU2001), to review and update the findings of PDTU 1991.

- 1) Road Plan
- 2) Public Transport Plan
- 3) Traffic Management Plan

##### **(2) Future Traffic Demand**

PDTU2001 forecasts that the travel demand for bus and car trips will increase sizably in the study area apace with population growth, especially pronounced in suburban residential areas. Total number of trips by bus and car are projected to approximately 1.8 times during the period from 2000 to 2020. The travel demand in 2010 will be increase to approximately 1.4 times in car and bus.

##### **(3) Proposed Road Plan**

PDTU2001 proposes the strengthening of arterial roads that connect Centro to growing suburban agglomerations on the basis of demand projections. The Road Plan recommends, *inter alia*, the extension and the improvement of the following four arterial roads. This Feasibility Study takes up the first three for evaluation.

- 1) Improvement of Av. Independencia
- 2) Extension of Av. Primeiro de Dezembro
- 3) Improvement of Av. Pedro Miranda
- 4) Improvement of Av. Liberdade

The implementation of these projects serves to improve the road network of the entire metropolitan area of Belem (BMA) in the following manner.

- 1) The major arterial axes connecting Centro to suburban areas are strengthened.
- 2) The existing major arterial roads will be widened and missing links are provided in the built-up area to create a more effective network of these roads.
- 3) The development projects mentioned above will form the backbone of BMA, and help solve the growing problem of traffic congestion with its attendant social



ramification. At the same time, they will create sufficient space on arterial roads to be used for more stable operation of public transport.

#### (4) Road Classification

PDTU2001 envisions the future road network of BMA by differentiating the functions of the existing roads. Clear classification of road functions enables to define the road space utilization, by differentiating, for example, those roads available for public transportation routing and others usable by general motorized traffic. It also makes it possible to secure the alternative routing for emergency.

PDTU2001 classifies the existing roads into three functional categories: namely, major arterial roads, arterial roads and collector roads. Major arterial roads define the structure of BMA, and include those roads connecting Centro to suburban areas and the ring roads inside and outside Centro. Av. Almirante Barroso, BR-316, Rodovia Augusto Montenegro, Av. Independencia, Primeiro de Dezembro and Av. Pedro Miranda are designated as major arterials that connect Centro to the suburbs.

Arterial roads are functionally complementary to the major arterials and comprise a number of ring roads and radials. Collector roads provide links between the major arterial and the arterial roads. They also serve as local arterials by linking newly developing areas to the existing arterial network.

Three of the major arterial roads, namely, Av. Almirante Barroso, BR-316 and Rodovia Augusto Montenegro, are expected to function as the trunk busway for public transportation. Figure 13.1-1 shows the functional classification of the road network in BMA.

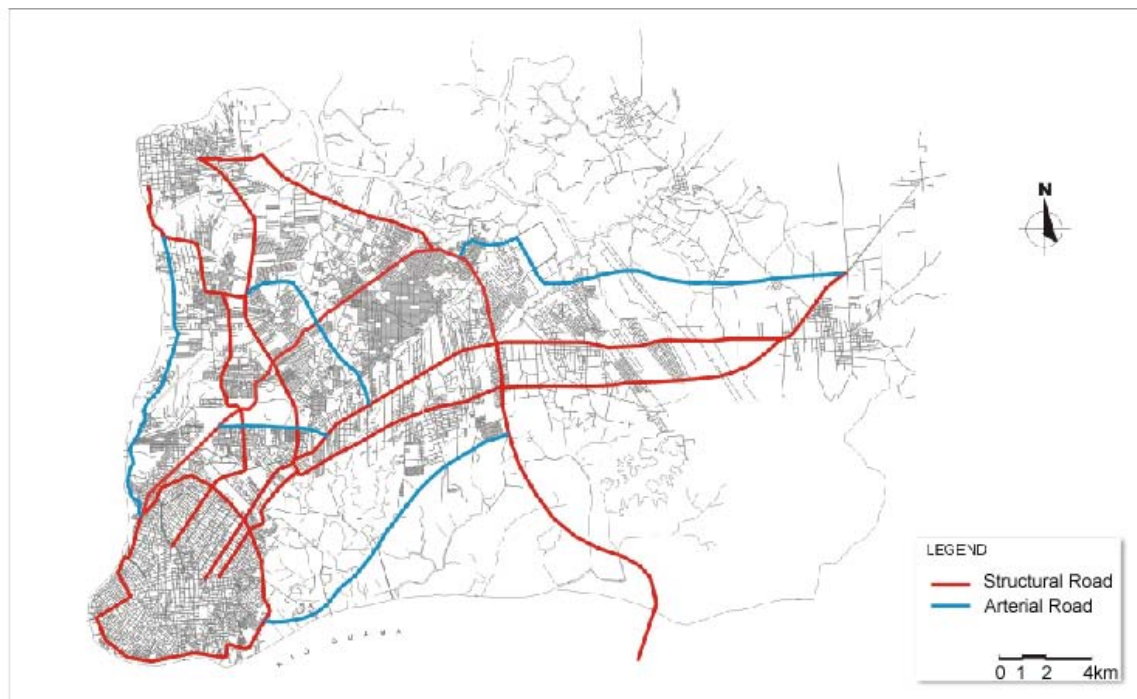


Figure 13.1-1 Road Functions in BMA



## 13.2. BASIC CONSIDERATION FOR ROAD PLANNING

### 13.2.1. ROAD PLANNING GUIDELINES

#### (1) Improved or Newly Constructed Road Projects

By weighing expected economic benefits and other factors, five priority projects have been selected from a list of road projects proposed by PDTU2001. This Feasibility Study examines the selected projects in accordance with the policies and strategies of PDTU2001, as described below.

##### 1) *Extension of Av. Primeiro de Dezembro*

The road is planned to share the function of BR-316, and the segment from Centro to the municipal border with Ananindeua is currently under construction. The proposed project extends this road up to Auca Viaria. Agua Preta Lake on the south of the proposed road site supplies water to Belem City. Therefore, the project must be designed to minimize the impact to this vital source of water. There are communities alongside the proposed site, indicating the need of relocation. The present study will examine the routing of the road so as to minimize the impact on these communities.

##### 2) *Improvement of Av. Pedro Miranda*

The road connects Centro to Icoaraci and is expected to share the function of Rodovia Augusto Montenegro. The project upgrades it into an arterial road that skirts around Belem Airport and links existing collector roads. The present road has two lanes and the alignment needs some improvement. The road will be widened to four lanes, but this requires land acquisition along the way. It will be necessary to design this project to minimize the relocation of local residents.

The proposed improvement includes the road section that crosses Julio Cesar Airport, for which PDTU2001 proposes an underground tunnel. The naval training base to the north of the airport is also an environmental conservation area. Therefore, the project requires careful route selection in this area. Environmental consideration and consultation with related organizations are essential for this project.

##### 3) *Widening of Av. Independencia*

This is a new state road that connects the north side of Centro to Cidade Nova and is expected to share the function of BR-316 and Rodovia Augusto Montenegro. Para State Government has been implementing this project by utilizing the ground level of the electric transmission line. The road has four lanes over the entire length from Centro to Alca Viaria. The present Feasibility Study examines the road widening and the intersection improvement to include the road into the proposed Trunk Busway System.

##### 4) *Improvement of Rua da Marinha*

The road connects up BR-316, Rodovia Augusto Montenegro, Av. Pedro Miranda and Av. Independencia. In other words, this road is expected to disperse the inbound traffic on the radial roads before entering Centro. The present Feasibility Study examines the widening and an extension of the road and the improvement of intersections to upgrade its function.

The road will be extended to cross Av. Almirante Barroso and BR-316 to fulfill its intended function. This extension and new intersections with two radial roads need land acquisition.

**5) Improvement of Link Road from Av. Primeiro de Dezembro to Cidade Nova**

The project establishes a link road between Av. 1<sup>o</sup> de Dezembro and Cidade Nova, by utilizing some existing road. There are a few alternative roads for this link. However, an extension of Avenida Mario Covas, the middle ring road in the study area, to Av. Primeiro de Dezembro appears promising, because this will strengthen its ring road function as well. The present Feasibility Study will evaluate the alternative routes to extend Avenida Mario Covas from BR-316 to Av. Primeiro de Dezembro and select the optimum route.

**(2) Trunk Busway Introduced Roads Project**

**1) Av. Almirante Barroso**

The avenue is the most important arterial road connecting Centro to the suburbs. Accordingly, the bulk of bus routes are now concentrated on this road. The Trunk Busway must be introduced here to realize an efficient bus operation system in the study area.

**2) Rodovia BR-316**

This road also plays an important role for bus routes. It directly connects to Av. Almirante Barroso and is important to bus users around Ananindeua. The Trunk Busway must be introduced here to realize an efficient bus operation system. In the future, Avs. Independencia and Primeiro de Dezembro will share the arterial function of this road, by taking part of the traffic load off this road.

**3) Rodovia Augusto Montenegro**

This municipal road connects to Av. Almirante Barroso and is important to bus users in Icoaraci. The Trunk Busway must be introduced here to realize an efficient bus operation system. In the future, Avs. Pedro Miranda and Independencia will share the arterial function of this road and take part of the traffic load off this road.

**4) Av. Pedro Alvares Cabral and Av. Senador Lemos**

Most of the bus routes pass Av. Almirante Barroso to reach Centro. Avs. Pedro Alvares Cabral and Senador Lemos are important as the secondary bus route, by diagonally crossing the transition area from Entroncamento and accessing Centro from the north. Two roads will be upgraded to serve as the Second Trunk Busway. They are now used as four-lane two-way roads, but will be changed to three-lane one-way roads, with one lane used as priority bus lane. The remaining road space will be used for the sidewalk with tree belt and the bikeway.

**13.2.2. PRELIMINARY ROUTE LOCATION**

The present Feasibility Study examines three principal arterial roads and two secondary arterial roads. Regarding Av. Independencia, construction works have been partly underway with adequate environmental measures. Therefore, it was thought appropriate to take the planned route for this road as given in the present 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. Changes have been judged realistic from the viewpoints of road functions and attributes, on the one hand, and of the possible social and environmental impact, on the other. The following is a description of partly changed route segments of the five roads. The remaining segments of the project roads involve the widening and improvement without any routing change.



**(1) Avenida Pedro Miranda****1) Road Segment that Crosses Julio Cesar Airport and the Navy Fusillade Training Center**

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 Tapaná to reach Icoaraci.

The proposed underground route segment to cross the airport (Prefeitura de Aeronautica de Belem) to Rua R. Chermont has four bottlenecks, and will have to be abandoned accordingly. The following is a description of the bottlenecks, of which the respective location is shown with corresponding number in Figure 13.2-1.

- 1) The construction of an underground tunnel of shallow depth below the civilian airport is beyond the experience of local construction companies. Moreover, it will be difficult to suspend the use of the runway that runs right above the proposed tunnel site throughout the construction period.
- 2) The airport authority plans to construct houses on the northern side of the runway. The routing of the proposed segment would be tortuously out of proper alignment, if it should skirt around the planned housing site.
- 3) To the north of the housing site lies a nature conservation area (Parque Presidente Medici), which will be expanded farther to include the area north of Rua da Marinha.
- 4) The Navy Fusillade Training Center is located in the area north of Rua da Marinha. It is out of the question to route the proposed segment across the naval shooting range.

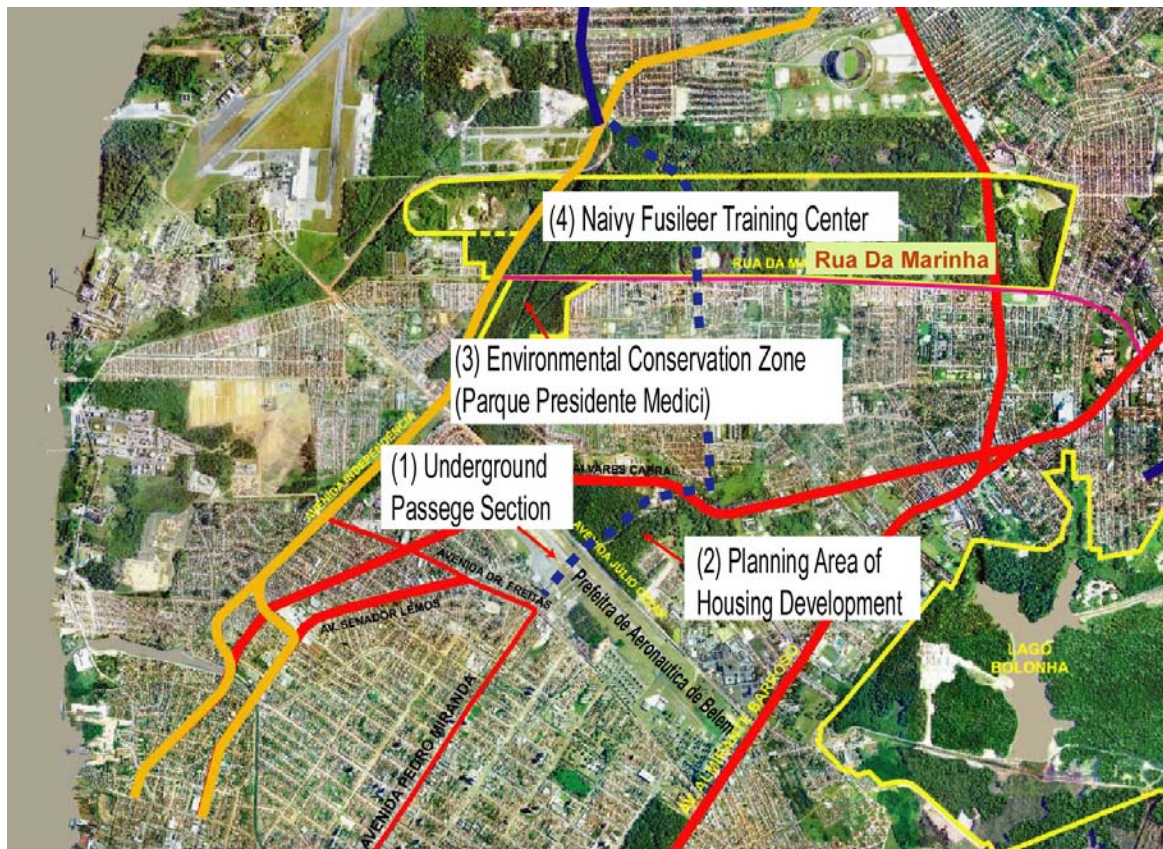


Figure 13.2-1 Abandoned Route Segment on Av. Pedro Miranda

## 2) Road Segment on Rua Yamada

Rua Yamada has an eastwardly curved route, which will be convenient to provide a direct link from Rod. do Tapaná to Rua R. Chermont. By taking into account the function expected of the route segment and the need of environmental measures including local community relocation, two alternatives are identified for preliminary examination. One alternative is to connect Rod. do Tapaná directly to Rua R. Chermont, and the other alternative is to connect Rod. do Tapaná via Rua Yamada to Rua R. Chermont. The location of two alternatives is shown in Figure 13.2-2.

- 1) Alternative-1: Direct connection from Rod. do Tapaná to Rua Rodolfo Chermont
- 2) Alternative-2: Connection from Rod. Do Tapaná to Rua Rodolfo Chermont via Rua Yamada

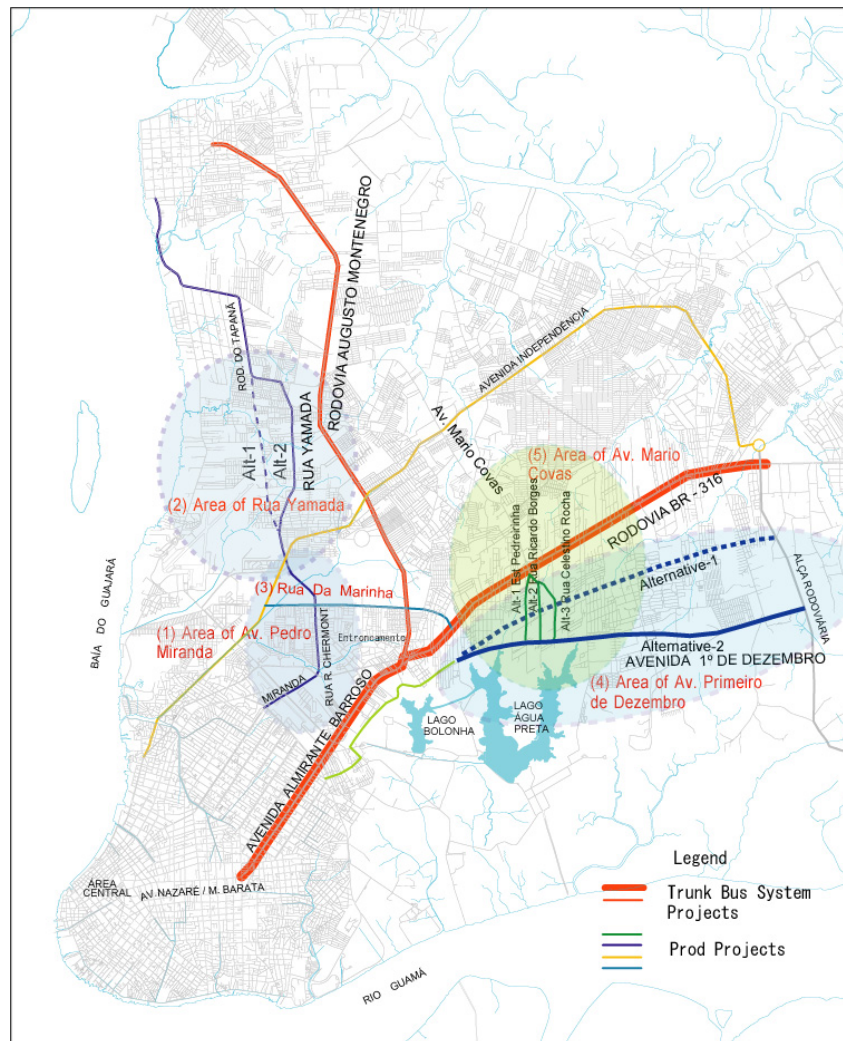


Figure 13.2-2 Alternatives for Three Proposed Road Extensions

The examination has found that Alternative-1 is better in alignment, but that it has serious disadvantages in other regards, as described below. Accordingly, Alternative-2, the initial proposal, is considered more feasible.

- 1) Alternative-1 has better alignment.
- 2) Alternative-1 effects the runway of Belem International Airport, and it will be difficult to shift the route.

- 3) Regarding the underground tunnel proposed for the airport section mentioned above, the low-lying terrain suggests the difficulty of drainage. In addition, Alternative-1 has to cross two streams, and this will increase its construction cost.
- 4) The relocation of roadside communities for site clearance is much larger in Alternative-1.

## (2) Rua da Marinha

This road runs next to the nature conservation area (Parque Presidente Medici). Therefore, it is necessary 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. Figure 13.2-1 shows the present condition of the area.

## (3) Extension of Primeiro de Dezembro

### 1) Route Location

There are two possible alternatives for the segment extending from Av. Primeiro de Dezembro, which is under construction by Belem Municipality, to Auca Viaria, as shown in Figure 13.2-2.

- 1) Alternative-1: The route runs one to two kilometers south of BR-316, and utilizes the existing roads as much as possible by widening them.
- 2) Alternative-2: The route runs further south of Alternative-1 through the more sparsely populated area to minimize the relocation of roadside communities.

Two alternatives have been compared and evaluated regarding their respective positioning in the entire arterial road network, possible site clearance requirements, route alignment in relation to local terrains, flexibility of road function vis-à-vis the future urban expansion, and ease of traffic management. As shown in Table 13.2-1 below, it has been found that Alternative 2 is better on most of the issues examined.

Table 13.2-1 Evaluation of Two Alternatives

Items for Evaluation	Alt-1	Alt-2	Remarks
Road network	×		Alt-1 is too close to BR-316.
Compensation for site clearance	×		Compensation for relocation is too costly for Alt-1.
	524 <sup>1)</sup>	328 <sup>2)</sup>	
Drainage	×		Alt-1 is too close to rivers.
Traffic movement			Alt-2 requires longer extension.
Flexibility to future urbanization	×		Alt-2 is more flexible to future urbanization.
Natural environment			Alt-1 is more environment-friendly.
Impact to roadside land use			Alt-1 requires relocation of more buildings.
Traffic management	×		Alt-1 requires more intersections.

Note:     : Good,     : Medium, and     × : Bad

1): estimated based on aero photograph taken in 1997

2): counted on field survey of this study in 2002



## 2) Planning Issues

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

- 1) The Belem municipality has its own plan for the segment of Av. Primeiro de Dezembro within the Centro and the construction works have been already underway for some time. The municipal plan adopts the road width of 32m, whereas the present Study proposes the width of 40m for the avenue extension. The cross-sectional details of the municipal plan are shown in Chapter 3 on Existing Development Plans in the Study Area. The difference in width comes from the provision of bikeway only on one side and the narrower sidewalk in the municipal plan. Coordination is necessary on how to connect the municipal side of the avenue segment and the proposed extension.
- 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 13.2-3 shows the present condition of the area around the proposed extension. Retaining walls are currently under construction around the lake to discourage trespassing. The area around the lake is designated as nature reserve. 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 to minimize adverse effects on the environment.
- 3) As shown in Figure 13.2-3, 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 will be necessary to provide some drainage structure below the embankment. The examination of this issue will be done during the preliminary engineering design stage.

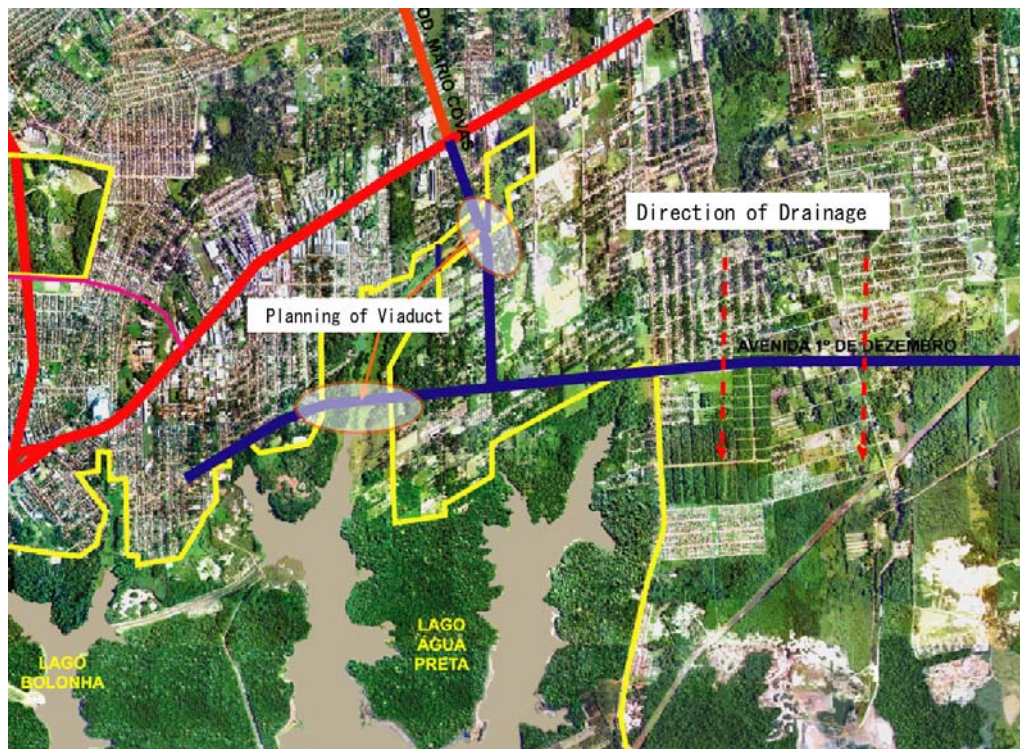


Figure 13.2-3 Present Condition around the Av. Primeiro de Dezembro Extension



#### (4) 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.

Avenida Mario Covas runs through the center of the rapidly growing area of BMA, serving as a ring road linking Av. Pedro Miranda, Rodovia Augusto Montenegro and BR-316. When Av. Primeiro de Dezembro is completed, the middle-ring-road function of Avenida Mario Covas will have crucial importance in BMA.

Three alternatives to connect Avenida Mario Covas to Av. Primeiro de Dezembro via BR-316 are compared and evaluated to find the best route. The location of the alternatives is shown in Figure 13.2-2.

- 1) Alternative-1: Utilization of Est Pedreirinha
- 2) Alternative-2: Utilization of Rua Ricardo Borges
- 3) Alternative-3: Utilization of Rua Celestino Rocha

To utilize the existing interchange on BR-316 and minimize the impact on the Conservation Area, Alternatives-2 and -3 offer better routing than Alternative-1. Alternative-3 has to pass the pond formed by the old sand quarry, and has disadvantages in road structure and surface water drainage. In terms of relocation requirements for site clearance, the possible impact on roadside communities and traffic management, Alternatives-2 and -3 are about equal. Accordingly, Alternative-2 is judged as the best route as shown in Table 13.2-2.

Table 13.2-2 Evaluation of Three Alternatives

Items for Evaluation	Alte-1	Alt-2	Alt-3
Usability of the existing interchange on BR-316	×		
Impact to the conservation area	×		
Traffic management			
Length of bridge or viaduct	×		×
Compensation for site clearance			
Impact to local inhabitants			

Note:     : Good,     : Medium, and × : Bad

#### (5) Avenida Independencia

##### 1) Location of Route Origin in the Centro

The fieldwork has found that the route origin within the Centro has to consider the following issues for planning. The present condition of the area is shown in Figure 13.2-4.

- 1) Av. Pedro Alvares Cabral intersects Rodovia Arthur Bernardes near the route origin. The resultant intersection of five roads in close proximity is a serious

traffic bottleneck, requiring difficult traffic management. Accordingly, the route should not originate from this location.

- 2) Para State proposes a route which crosses the river found near its origin. This requires the construction of a large bridge of some 200m in span. To reduce the huge cost of such construction, it is necessary to consider the possibility of detour before the proposed river crossing point.
- 3) The area between the proposed bridge and the route origin is densely packed with houses. The construction of a six-lane road in the midst of this area necessarily involves large-scale relocation. Therefore, it is desirable to change the location of this route segment.
- 4) 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 13.2-4.

## 2) Route Location near Parque Presidente Medici

The initially proposed routing of Av. Independencia passed through Parque Presidente Medici. Because it is not allowed to plan a major arterial inside this nature conservation area, the alternative route is proposed to skirt around the park in consultation with FUNVERDE (Fundacao dos Parques e Areas Verdes de Belem). The new route location is shown in Figure 13.2-1.



Figure 13.2-4 Present Condition around Route Origin of Av. Independencia

### (6) Proposed Route Location

As mentioned above, the alternative routes of three proposed roads were examined and the most optimum route was selected from road functions and attributes and also from the viewpoint of the possible social and environmental impact.

In the feasibility study, the road planning will be carried out under the selected route locations as shown in Figure 13.2-5.

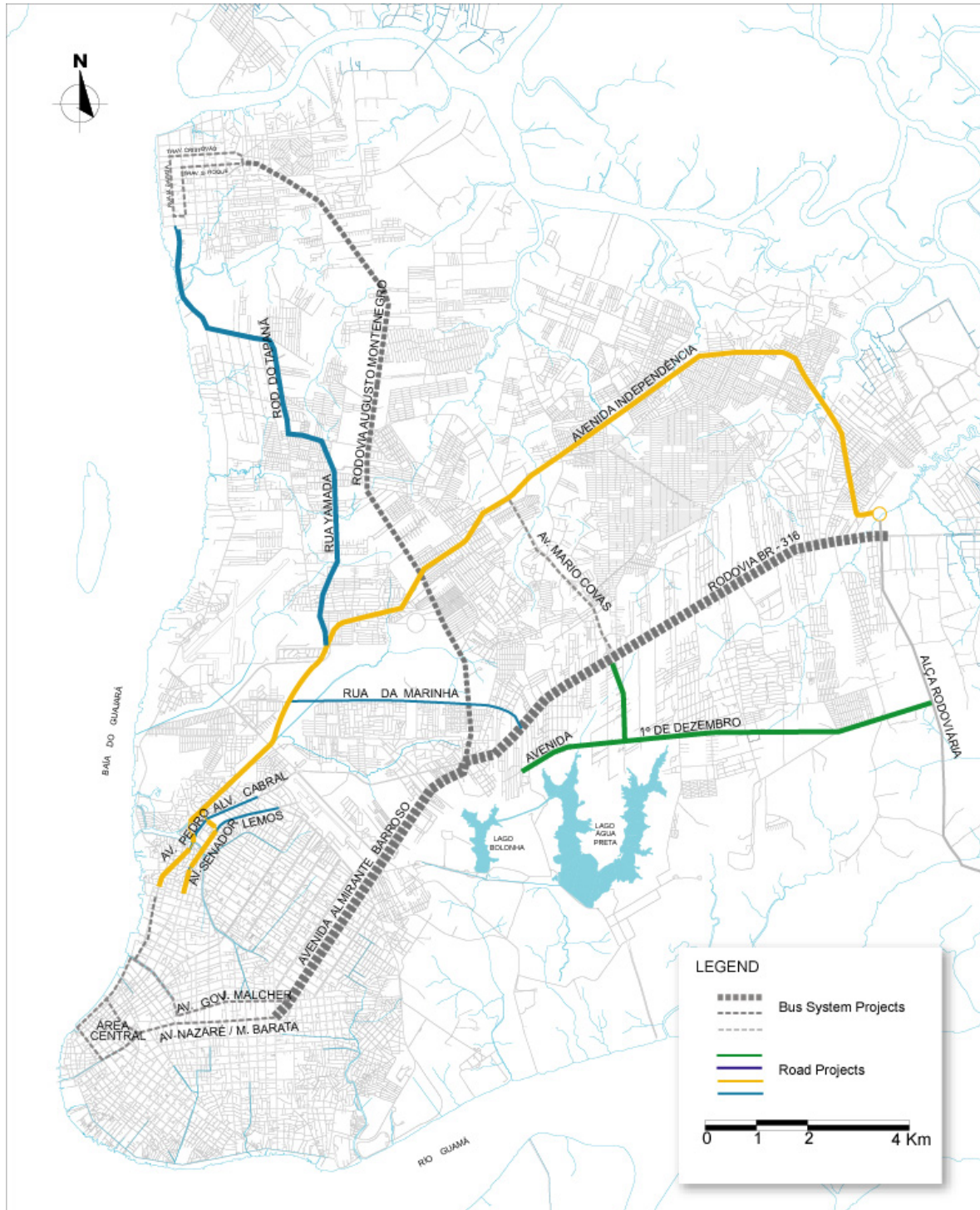


Figure 13.2-5 Proposed Route Locations