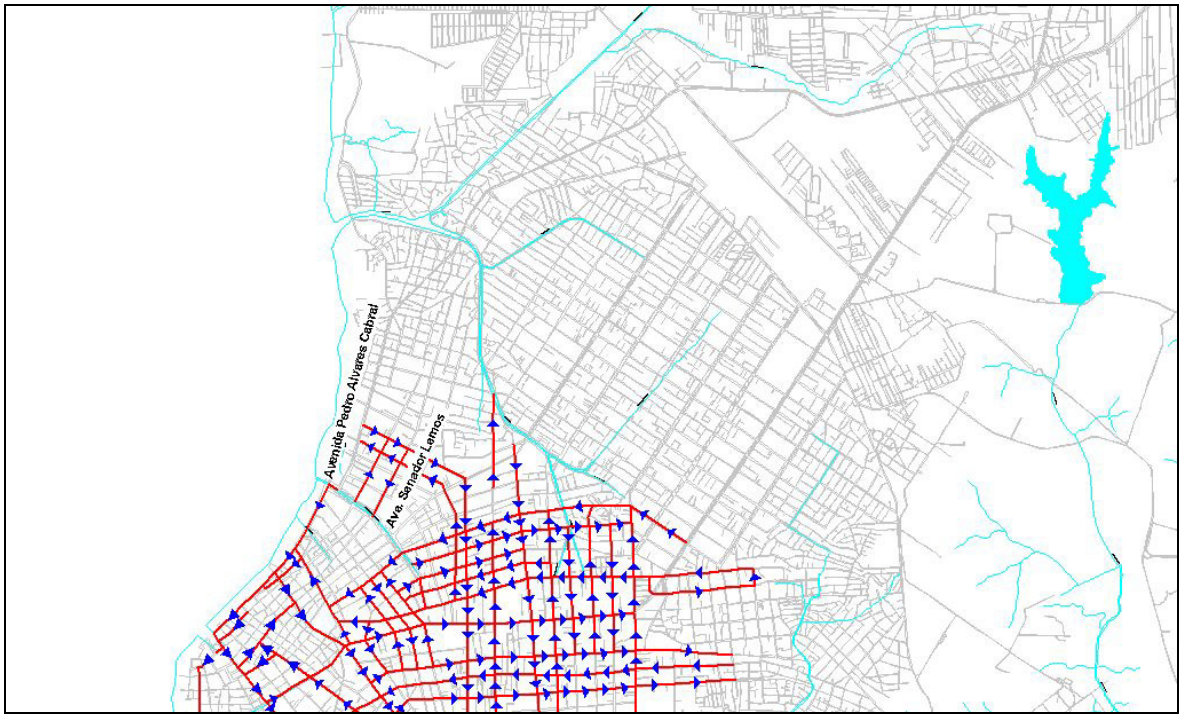
Current Traffic Management System



Proposed Traffic Management System

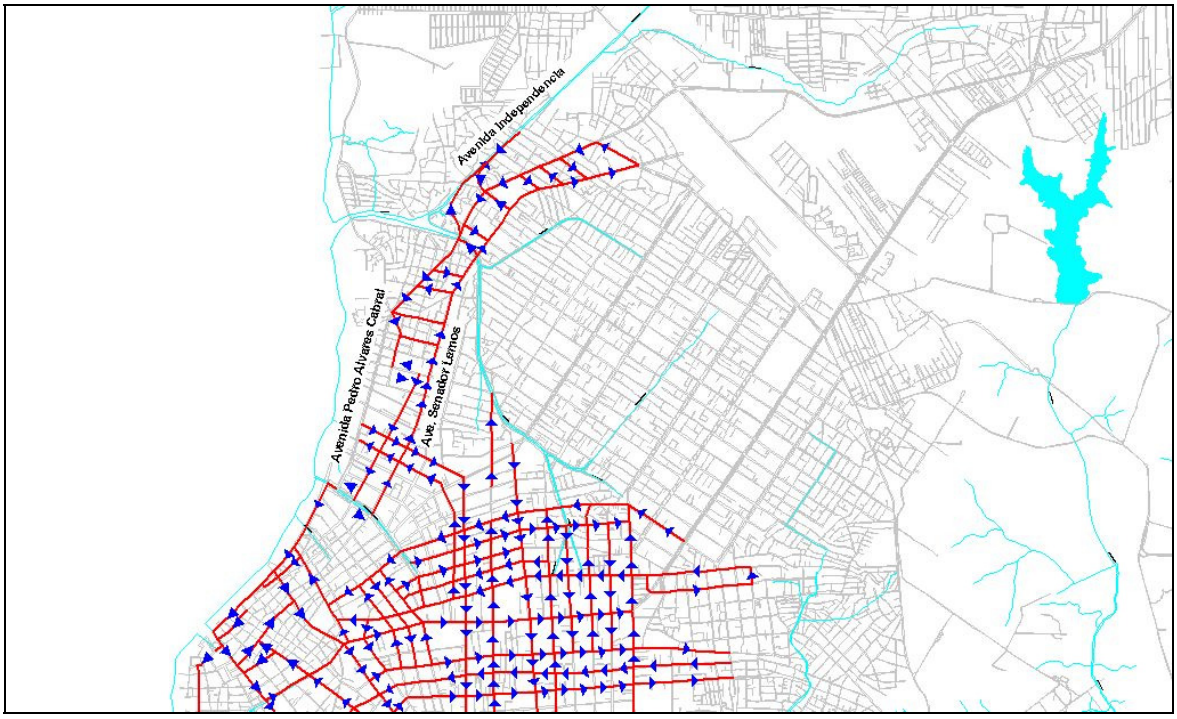


Figure 14.3-7 One-way Traffic Management Plan near the Beginning Point of Avenida Independencia

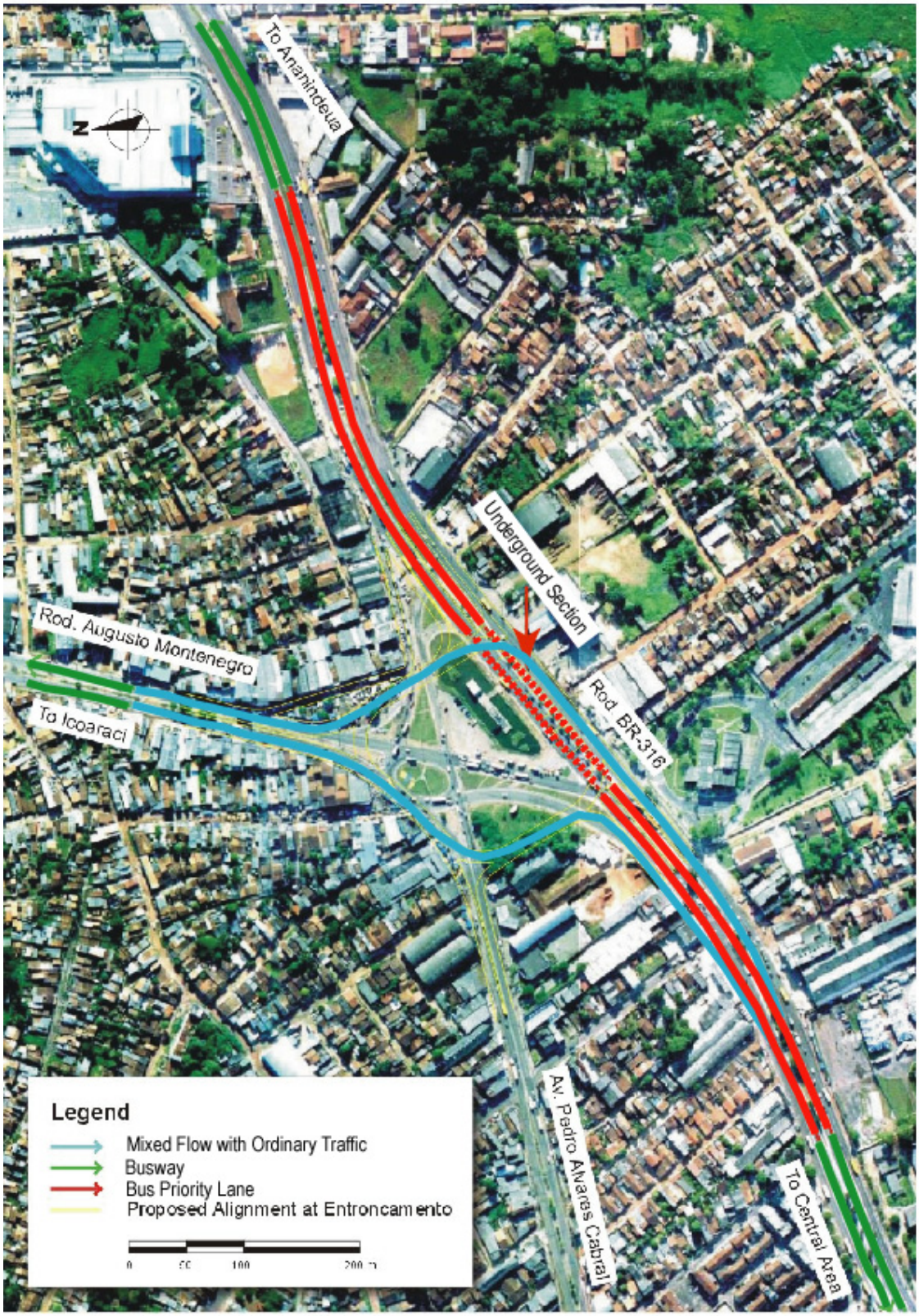


Figure 14.3-8 Bus Flow Movement Plan of Busway at Entroncamento

14.3.7. VOLUME OF WORKS

Av. Independencia is currently divided into three segments; 1) those segments under construction, 2) those segments with completed structures except asphalt paving, and 3) those segments with detailed designs only. Figure 14.3-9 shows the progress of construction on Av. Independencia. Costing of exclusive bus lanes is done in two ways. Regarding the completed segments, the costing concerns the widening works needed to introduce the lanes, as shown in Figure 14.3-10. For the segments under construction or with detailed design only, the costing covers the entire construction works.

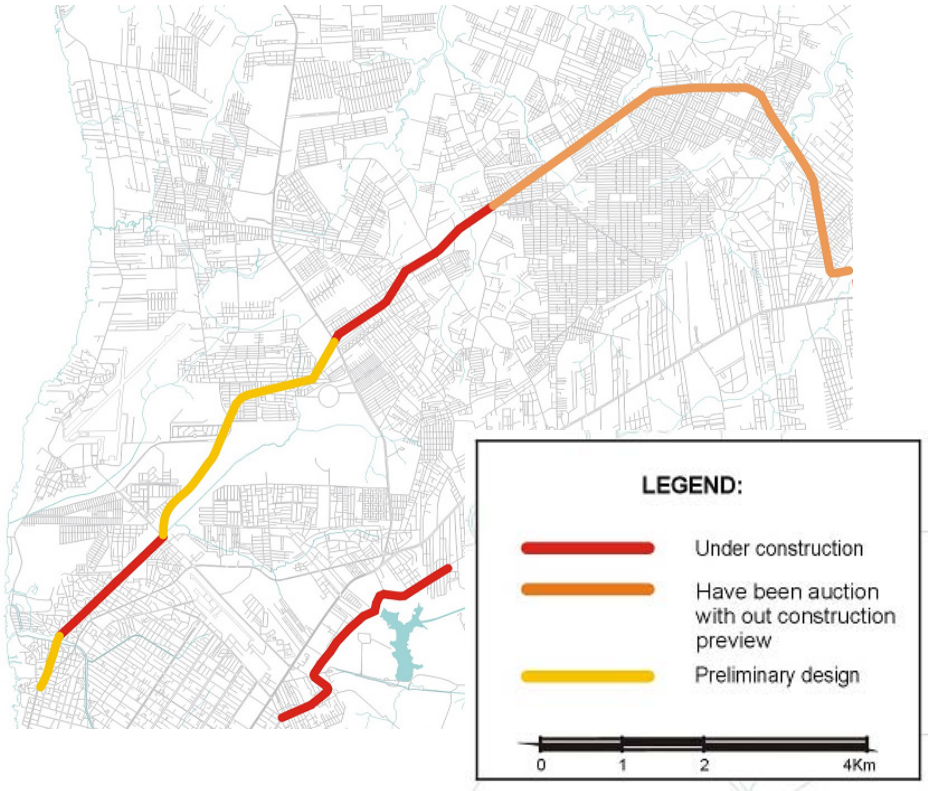


Figure 14.3-9 Progress of Construction on Av. Independencia

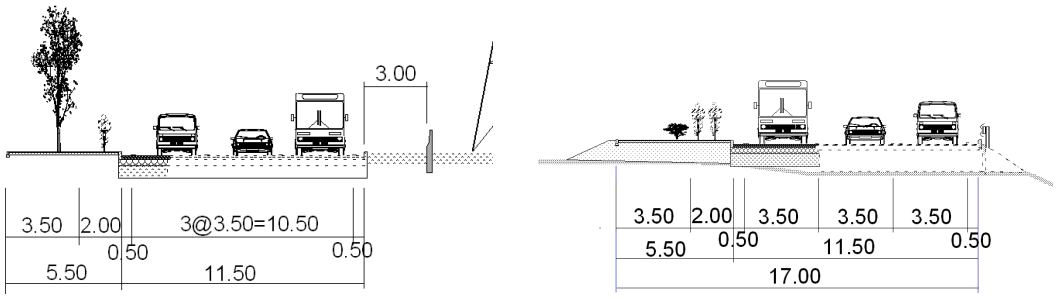


Figure 14.3-10 Cross Sections on Widening Segments Assumed for Costing

14.4. PRELIMINARY DESIGN OF BUS PRIORITY LANE

14.4.1. GENERAL

The trunk bus priority lane uses the right-side lane of the existing roads. The priority lane is marked by its colored pavement to be distinguishable from through traffic lanes.

Motorized vehicles other than buses can drive on the priority lane off the bus priority hours. Figure 14.4-1 shows the roads selected for introducing bus priority lanes in the built-up area of Icoaraci. Figure 14.4-2 does the same within the Centro of Belem.

Figure 14.4-1 Bus Priority Lane in Icoaraci

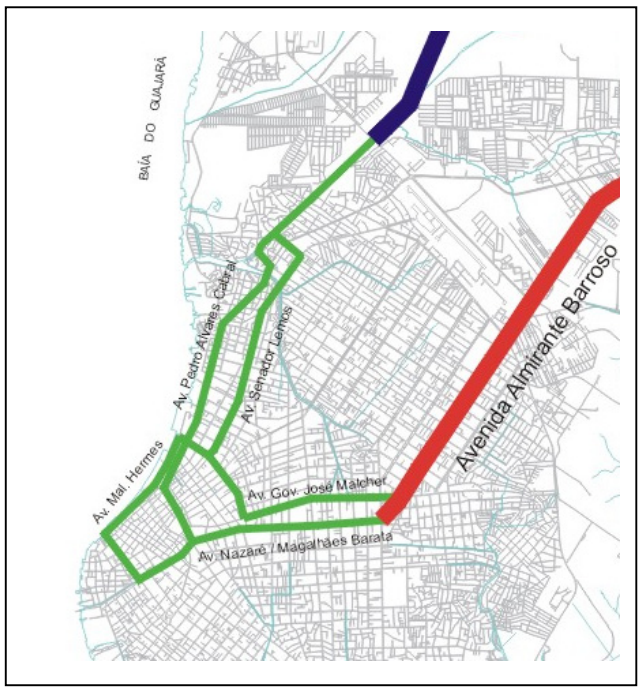


Figure 14.4-2 Bus Priority Lane within the Centro of Belem

14.4.2. ALIGNMENT DESIGN

(1) Horizontal Alignment

The trunk bus priority lane uses the right-side lane of the existing roadway, without any improvement in horizontal alignment.

(2) Vertical Alignment

The design follows the respective vertical alignments of the roads selected for introducing the bus priority lane.

14.4.3. CROSS SECTION DESIGN

The design conforms to the respective cross sections of the roads selected for the bus priority lane. Figure 14.4-4 shows the cross section of Av. Pedro Alvares Cabral and Av. Senador Lemos. Those roads are planned as a one-way traffic road on a counterclockwise one-way circulation system. Those roads connect to Av. Independencia: Av. Pedro Alvares Cabral is the southbound direction while Av. Senador Lemos is in the direction of northbound as shown in Figure 14.3-5. Figure 14.4-4 shows the cross section of an existing two-way four-lane road in Centro of Belem, changed into a one-way road after introducing the bus priority lane.

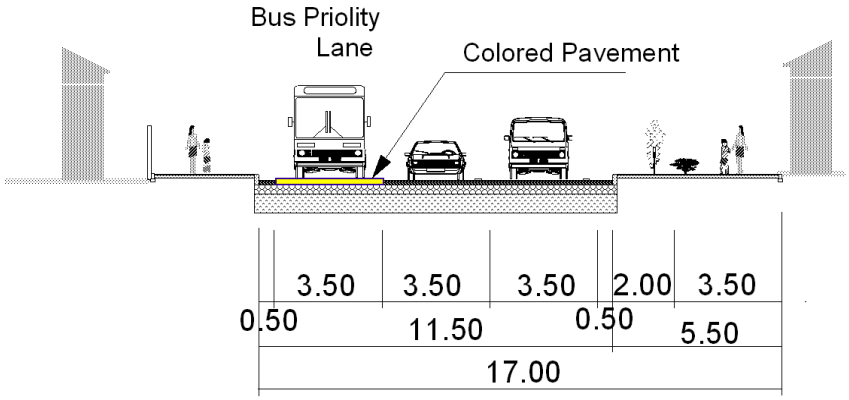


Figure 14.4-3 Av. Pedro Alvares Cabral / Av. Senador Lemos

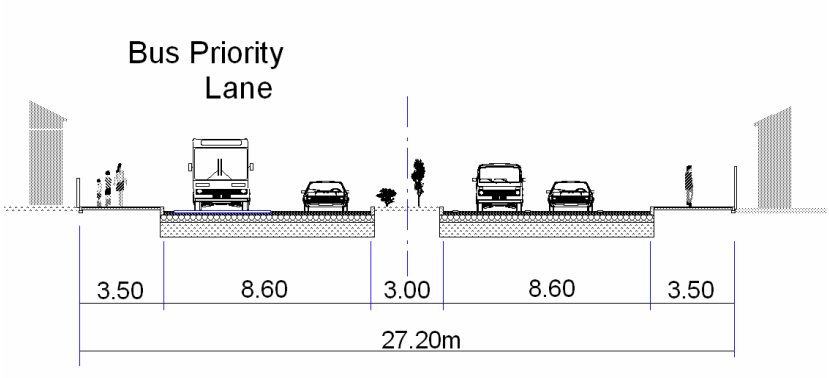


Figure 14.4-4 Cross Section Design for Bus Priority Lane in Centro of Belem

14.4.4. PAVEMENT DESIGN

In order to clearly distinguish the bus priority lane from the other lanes, the colored pavement is overlaid on the asphalt surface.

14.4.5. INTERSECTION DESIGN

The design conforms in principle to the existing types of intersection. The bus lane on bus tracks to turn at intersection is overlaid with the concrete pavement. Figure 14.4-5 shows the location of the concrete pavement at intersection.

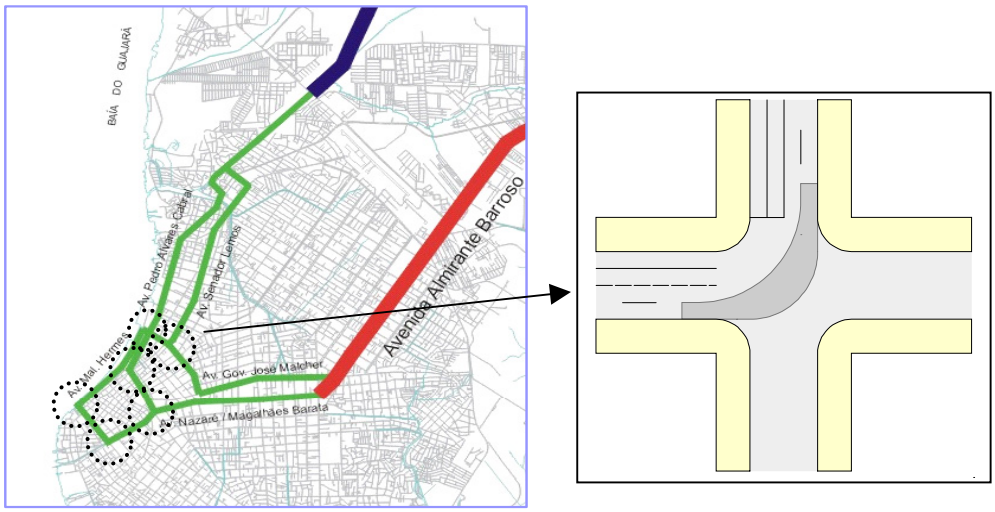


Figure 14.4-5 Location of Concrete Pavement at Intersection

14.4.6. VOLUME OF WORKS

One-way traffic control is put into effect on the roads selected for the bus priority lane in order to raise their transport capacity. It will be necessary to relocate the median with the introduction of one-way traffic control. Table 14.4-1 shows the extension of colored pavement by road in the Centro and Icoaraci.

Table 14.4-1 Extension of Colored Pavement by Road

Road	Length (m)
Total Extension in Icoaraci	3,271
Trav. Cristovao	1,566
Trav. Sao Roque	1,705
Total Extension in the Centro of Belem	25,570
Av. Governador Jose Malcher	2,225
Av. Magalhaes Barata	2,636
Av. Visc. de Souza Franco (north)	1,504
Av. Visc. de Souza Franco (south)	430
Av. Malcher Hermes	1,748
Av. Visc. de Souza Franco	1,504
Rua Ignacio Guihon	813
Av. Alm. Tamandare	940
Av. Assis de Vasconcelos	890
Bourevardo Castilho Francia	680
Av. Visc. de Souza Franco	1,504
Av. Pedro Alvares Cabral	2,720
Av. Senador Lemos	3,070
Av. Independencia (north)	2,513
Av. Independencia (south)	2,393

14.5. INTEGRATED BUS TERMINALS

14.5.1. BUS OPERATIONAL FLOW TO/FROM BUS TERMINAL

There are eight (8) integrated new bus terminals and one (1) existing improved terminal along the busway. The inflow and outflow plans to/from these integrated bus terminals in the trunk bus operation are made based on the shape and size of the terminal and configuration of the access road. The operation flows to/from those integrated bus terminals, exclusive of the Icoaraci, Tapana, Coqueiro and Sao Bras bus terminals, are right or left-turn to the roadside from the trunk busway, which is located at the center of the road. The locations and types of integrated bus terminals are shown in Figure 14.5-1. The planned operational flows at the Icoaraci, Tapana, Coqueiro and Marituba bus terminals and other integrated bus terminals are shown in Figure 14.5-2. The planning concept for the trunk bus operational flow to/from the integrated bus terminals is as follows:

1) In order to minimize the traffic congestion around the integrated bus terminals, the entrances and exits to/from the bus terminals are limited to only one or two as much as possible.

2) In order to minimize the conflict between buses and passengers, the bus operational flow is simplified as much as possible.

3) Bus-priority traffic signals are installed for smooth inflow and outflow to/from bus terminals and priority is given to trunk buses when buses are going in or coming out to/from the bus terminals.

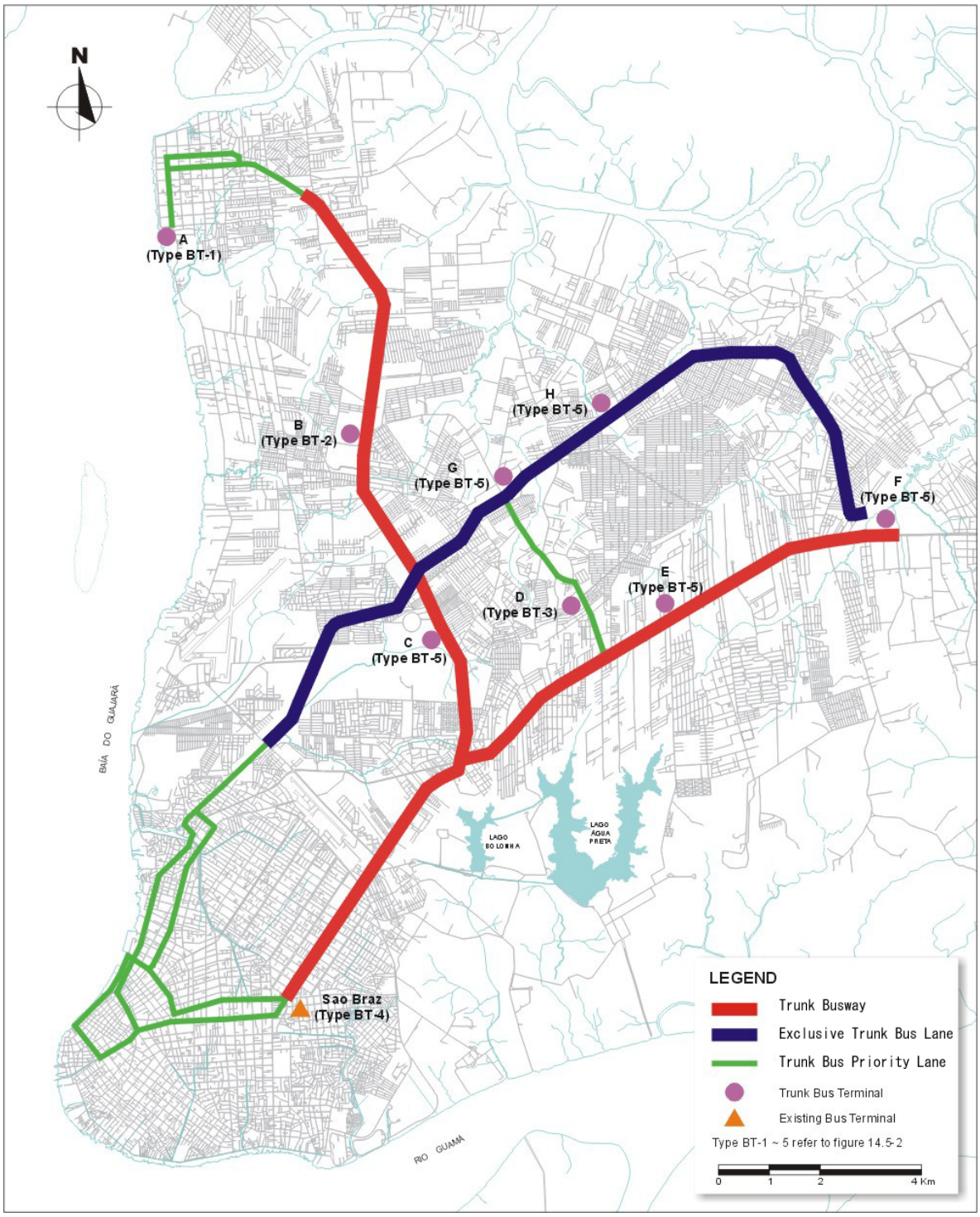


Figure 14.5-1 Location and Type of Integrated Bus Terminals

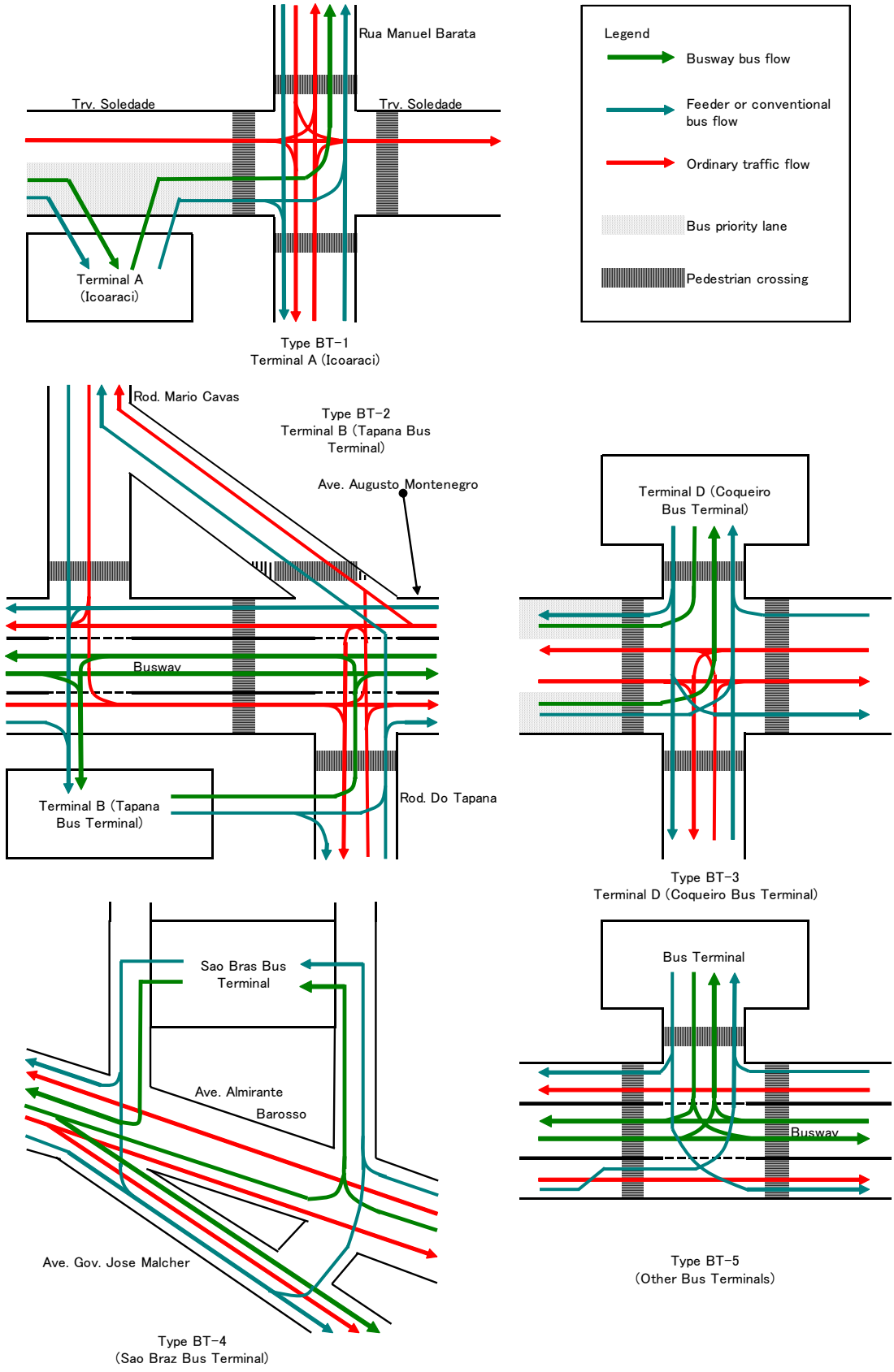


Figure 14.5-2 Bus Operating Flows To/From Integrated Bus Terminals by Terminal Type

14.5.2. DESIGN BASIS

(1) Design conditions of the buses

The specifications of each type of bus depend on the manufacturer. The following specifications are considered as the largest and are used in the design.

Table 14.5-1 Design Conditions

	Ordinary bus*	Articulated bus
Length	(11～)13m	(16～)18m
Width	2.5m	2.5m
Height	3m	3m
Minimum turning radius	(12～)14m	(12～)14m
Minimum width for U-turn	(18～)24m	(24～)28m

* Conventional bus and feeder bus. The feeder bus will be same or smaller than the conventional bus.

(2) Functions for the integrated bus terminal

The following functions are expected for the integrated bus terminals:

- Efficient and convenient transfer between the trunk bus and the feeder bus (free transfer)
- Collection of bus fare from entering passengers and sales of tickets
- Safety of passengers
- Smooth driving and stopping of buses
- Parking of buses for adjustment of time and rest of drivers
- Administration of bus operation
- Consideration for use of the mobility impaired (elderly people with canes, wheelchair users, etc.)
- Amenity in usage (bench, floor finish design, design for the signs, design of architecture, toilet, parking for bicycles, etc.)
- Passengers' convenience (shop, coffee shop, information, lottery ticket sales, recycling commission space, exhibition space, etc.)
- Contribution to urban development (commercial, business, cultural, public services, etc.)

(3) Location of integrated bus terminals

The locations of the integrated terminals are allocated as shown in Figure 14.5-3.

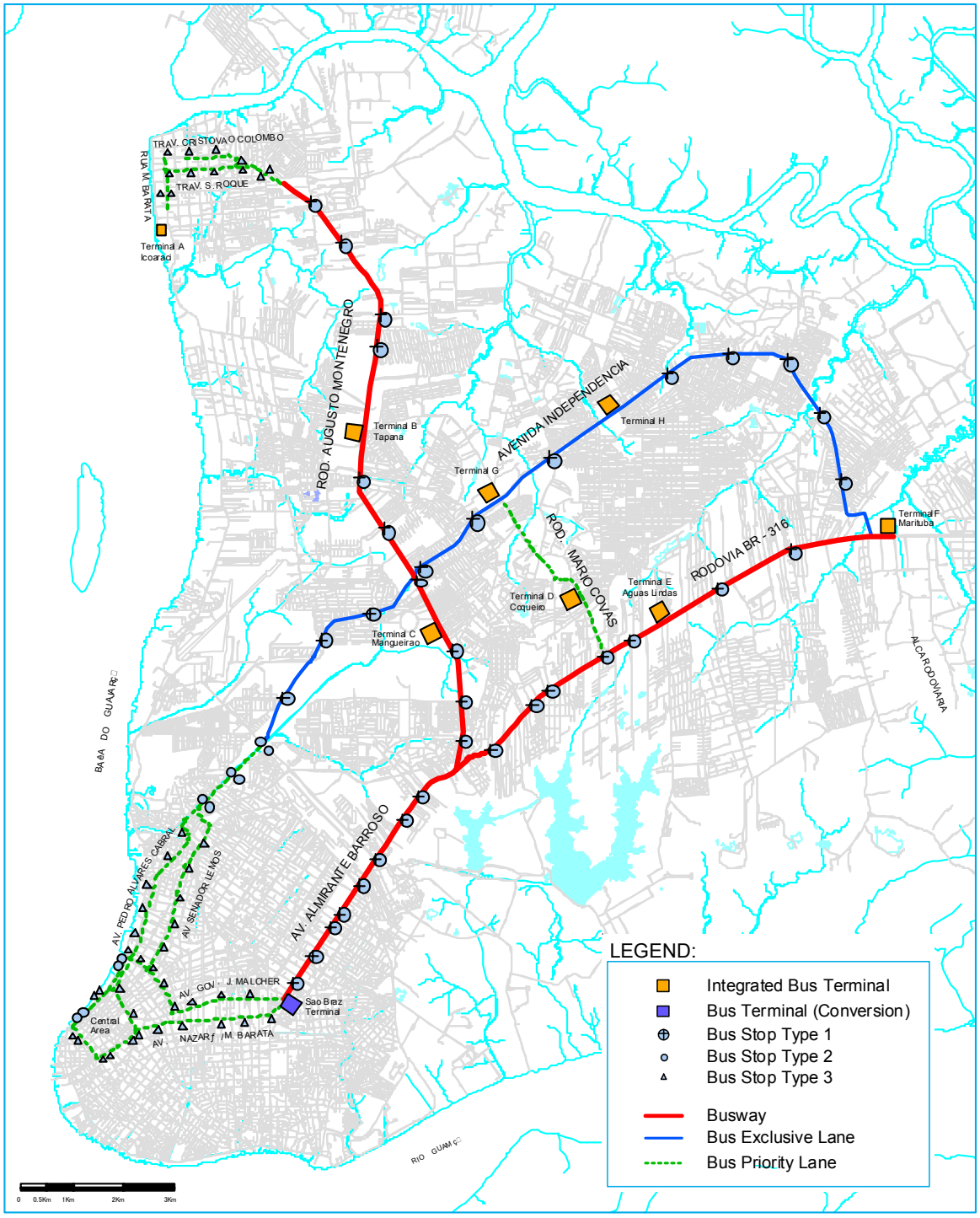


Figure 14.5-3 Locations of Bus Terminals and Bus Stops

(4) Land Use in and around the site

Table 14.5-1 shows the outline of the present land use in and around the sites.

Table 14.5-2 Outline of the Present Land Use

Terminal		Land use condition around the site
A	Icoaraci	Periphery of urbanized area. Former cement depot. Facing the river. Jetty development is planned. The existing depot is on the south side. The opposite side of the road (east side) is a residential area.
B	Tapanã	Unused open field. The opposite side is a triangle rotary of Av. Mario Covas.
C	Mangueirão	Unused open field next to the planetarium and the parking of the stadium.
D	Coqueiro	Crossing of Av. Mario Covas and Av. Três Corações. Mostly an unused field. Electricity transmission lines and the poles should be avoided. A small office and store are on the south. A gas station and motel are on the opposite corner. A supermarket is adjacent to the gas station.
E	Águas Lindas	Now a private bus station. There are largely industrial facilities such as warehouses in the vicinity. There are houses to the rear. There is an open field on the opposite side of Rod. BR-316.
F	Marituba	Unused large former factory site. Abandoned buildings. There are industrial facilities such as a gas station and warehouses on the opposite side (south side).
G	Independência 1	Mostly undeveloped land. Accessible on unpaved Av. Independencia. Houses along the road.
H	Independência 2	Undeveloped land. Not accessible.
	São Braz	An existing and operating long-distance bus terminal. In a busy commercial area.

14.5.3. DESIGN OF BUS TERMINALS

(1) Types of the integrated bus terminal

In general, there are the following types of bus terminals according to the layout of bus berths, having the following advantages and disadvantages (see Table 14.5-3).

Table 14.5-3 Advantages and Disadvantages by Type of Bus Terminal

Type	Advantages	Disadvantages
A. Two-sides one-platform type (one long platform, berths on both sides, buses run in opposite directions)	Short frontage, compact, concentrated use of facilities, simple bus route and entrance-exit, easier extension	Long distance to walk for passengers
B. Two-sides two-platform type (two-platforms, berths on both sides, buses run in opposite directions)	Increased number of berths, separation by direction of routes, shorter walking distance	Increased crossing of passengers and buses
C. Polygon type	Easier stopping along curb, concentrated use of facilities, symbolic shape	Larger site area (difficulty in expansion)
D. Parallel type (multi-platform, berths on one side)	Possible to provide many berths, no crossing of bus courses	Inconvenient transfer, crossing of passengers and buses
E. Combination of B and D	Possible to provide many berths	Inconvenient transfer, crossing of passengers and buses

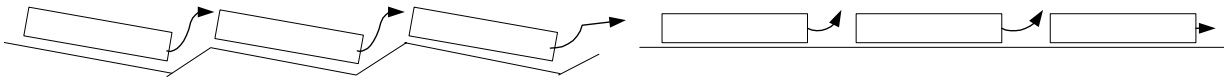
(2) Berth type

For bus berth types, there are the straight type and the obtuse zigzag type. The straight type is adopted considering convenience and efficiency of passenger facilities. Table 14.5-4 shows the berth types.

Table 14.5-4 Berth Types

Berth type	Advantage	Disadvantage
Straight	Simple shape, easier transfer	Difficulty in stopping along curb in case another bus is parked behind the berth*
Obtuse zigzag	Easier stop touching curb	Difficulty in checking safety by side mirror, wider platform area, angled layout of facilities

* The bus could stop along the curb in case of sufficient interval of the berths.



(3) 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 14.5-4 shows the basic function of the integrated bus terminal.

The characteristic of the integrated bus terminals of this project 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.

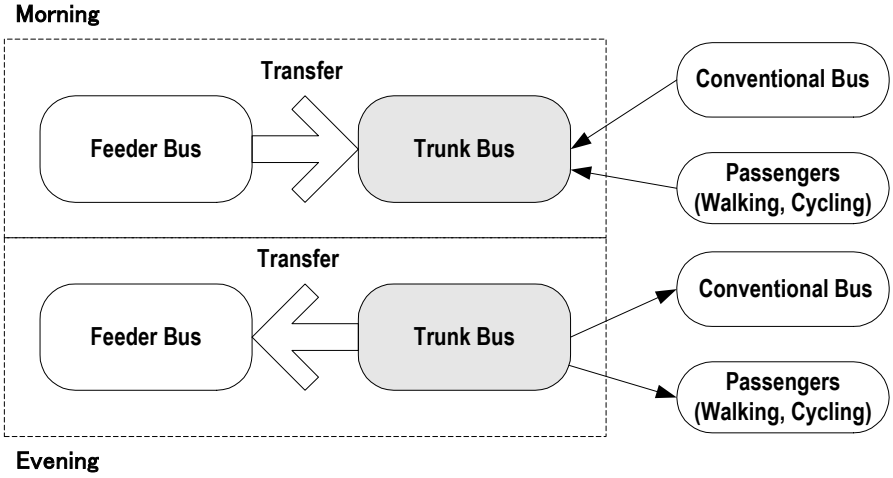


Figure 14.5-4 Basic Function of Integrated Bus Terminal

(4) Consideration for the mobility impaired

For easier use by all passengers including the handicapped and the aged, the following should be considered at least:

- Slope of 1/20~1/12 for each step (difference in level)
- Minimum width of 1.8m (clearance)
- Non-slip floor finish
- Handrails for steps and slopes

(5) Design idea for integrated bus terminal

Design ideas are as follows:

- The terminal will be enclosed with walls and the passengers will be checked at the entrance and exit gates.
- The berths for trunk buses should face the berths for feeder buses (pair of boarding and alighting facing each other) for efficient transfer.
- Differences in grade will be avoided, for easy passenger movement including the handicapped.
- The space should be convenient and pleasant for passengers.
- Passenger service facilities such as toilets, shops, kiosks, coffee shops, and lotteries will be provided.

(6) Facilities in the integrated bus terminal

1) Platform (see Figure 14.5-15)

The major activity (transfer) is done in the platform. The platform is covered, with the roof projected to the bus side to shield it from the rain. In the center of the roof, high side lighting and ventilation windows will be made.

The benches will be provided with a short back wall that separates them from the shops. Kiosks and open-type coffee shops with counters will be provided in the center of the platform. They will not disturb the vista from one end to the other.

The waiting room for the drivers and conductors with storage will be located on the opposite end of the platform near the bus parking.

2) Width of berth side

To allow for the full capacity of the articulated bus (200 people) to gather at the side of the bus, the width will be as follows:

$200 \times 0.33 \text{ (people/m}^2\text{)} / 18\text{(m)} = 3.7\text{m} \rightarrow 4\text{m}$

By the standard for railway stations in Japan, the capacity of pedestrian passage is 2,500 people/hour per meter wide. It should be enough for the estimated number of passengers. Considering the peak load, the width for Terminal B: Tapana, C: Mangueirao and E: Aguas Lindas would be 5m, and that for D: Coqueiro and F: Marituba would be 6m.

The width of 1m for the benches should be added up to the short walls of the shops in the center.

3) Passenger building (see Figure 14.5-14)

The bus terminal will be enclosed with walls or fences. The in-coming and out-going passengers will be checked at the ticket gates. The passenger building will be constructed in the front part of the bus terminal, accommodating ticket gates; an office with ticket and information windows with storage; shops and toilets. A convenience

store, a coffee shop, lottery ticket sales, and so on will be introduced for the convenience of passengers.

4) Pedestrian crossing

The passengers from conventional buses, on foot and by bicycle, will approach from the passenger building to the platforms through pedestrian crossings. The pedestrian crossings will be raised (about 75mm) to secure the safety of passengers against the buses.

5) Taxi stand

A taxi stand will be prepared in front of the passenger building. The end of the sidewalk will be used as loading and unloading space for private cars. The access road will be segregated from the bus road where it could be used as extra parking space for taxis.

6) Reserved lot to be leased for shop

The lots along the main road will be leased to tenants, who will be responsible for making the shop buildings by themselves.

7) Bicycle parking

Judging from the OD, there are many bicycle trips. Bicycle parking should be provided in front of the terminal. In this space it is possible to have events, open markets or exhibitions on weekends. Bicycle and walking trips will contribute to commercial development around the terminal with increased flow of people.

8) Planting

Planting space and flowerbeds will be provided between the leased lots and the bicycle parking. This space could be used for future extension of bicycle parking or shops. The perimeter zone along the boundary walls will be planted with trees and shrubs.

9) Bus parking and U-turn space

After the feeder buses unload the passengers, they will make a U-turn and stop at the boarding berth or will park until the next scheduled starting time. U-turn space will be provided at the end of the site (opposite end from the platforms) with parking of the feeder buses. The trunk buses (articulated buses) will park along the bus lane or along the boundary wall.

10) Gate and control box

At the entrance and the exit for the buses are the gates and the control box for the controller, who will check the in-coming and out-going buses as well as keeping passengers out.

11) Car parking

To promote use of “park and ride,” car parking should be provided in the vicinity of the integrated bus terminal if possible. As a large area is required for parking, it will be reserved only at Mangueirao terminal. There is a possibility at Marituba, Tapana, Independencia 1 and 2 terminals. To prevent crime to the parked cars, an open site with a clear view is preferable.

(7) Ticketing and bus doors

The introduced articulated buses will have four doors in total, with two doors in each car. In the integrated terminals, the passengers may use all four doors for alighting and boarding without checking. They should be checked at the entrance gate of the terminal.

At the stops, passengers should pay or show the tickets on boarding.

A conductor will be on the rear car and he can give cash service with change. At the front door, the driver will check only tickets or tokens (no cash).

(8) Number of berths

The number of berths is designed from the following point of view:

- The berths should be provided by direction. The waiting place for one destination should not be allocated to more than two berths except in the neighboring areas. The passenger might wonder which berth to wait at if several berths were provided for the same destination.
- An long queue should be made by berth or by direction. Disruption of the line should be avoided.
- In case the interval of the buses is shorter than the boarding and alighting time, an extra berth should be added.

1) Estimated number of passengers in 2012

The estimated number of passengers by integrated terminal is as follows:

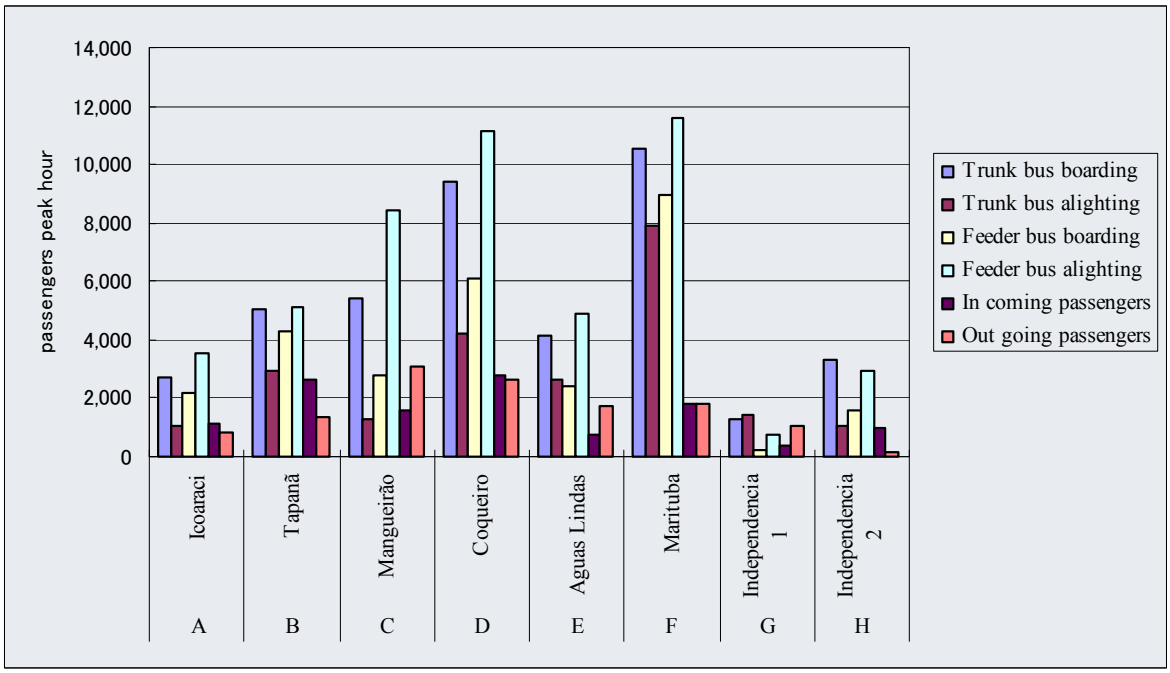


Figure 14.5-5 Estimated Number of Passengers in 2012 by Terminal

* The total is not the same as the numbers of boarding and alighting because there are passengers who alight from a trunk bus and board another, or alight from a feeder bus and board another.

2) Capacity of bus berth

a) Trunk bus (starting point of route)

- Based on the survey in this study, the boarding or alighting time per passenger is about 10 seconds. To find the interval, it is necessary to add the opening and closing time of the door, the time for leaving and the time for the next bus to stop. It is assumed to be about 20 seconds.
- Passengers equaling 80% of the capacity of the bus (200 x 0.8 = 160) can board to have room for the passengers en-route.
- The articulated bus will have four doors. The passengers can board from any door, as the transfer is free.
- The interval is calculated as follows with 10 seconds margin (extra):
  2 x 160 / 4 + 20 + 10 = 110 (seconds) [Maximum frequency: 3600 / 110 = 32]
- The capacity of the berth is as follows:
  160 x 3,600 / 110 = 5,230 (passengers per hour)

b) Trunk bus (en-route)

The berth en-route should be one per direction, as there will be one bus lane.

The maximum frequency will be 3600 / 30 = 120 per hour.

c) Feeder bus

- The feeder bus is assumed to carry 80% of the capacity (70 x 0.8 = 56 passengers).
- The interval from closing the door to the stopping and door opening of the next bus will be about 20 seconds with margin, as the next bus can quickly follow the previous bus.
- The feeder bus will have two doors.
- The interval is calculated as follows:
  2 x 56 / 2 + 20 = 76 (seconds)
- The capacity of the berth is as follows:
  56 x 3,600 / 76 = 2,650 (passengers per hour)

3) Calculated number of berths and designed number of berths

Table 14.5-5 shows the calculated number of berth based on the capacity of a berth. The number of berths was designed from the number of destinations and the capacity, as well as the pair of the trunk bus berths and feeder bus berths.

Table 14.5-5 Number of Bus Berths

Berth	Trunk bus							Feeder bus			
	Inbound				Outbound			Boarding		Alighting	
Terminal	For São Braz	For Inner Indepen-dencia	Inbound En-route	Inbound Designed	Outbound Only	En-route	Outbound Designed	Calculated	Designed	Calculated	Designed
A Icoaraci	1	1	-	2	1	-	2	1	3	2	3
B Tapana	1	1	1	3	1	1	3	2	5	2	5
C Mangueirao	1	1	1	3	1	1	3	2	5	4	5

D	Coqueiro	2	1	-	3	1	-	3	3	5	5	5
E	Aguas Lindas	1	0	1	2	1	1	2	1	3	2	3
F	Marituba	2	1	-	3	2	-	3	4	5	5	5
G	Independencia 1	1	1	←	2	1	1	2	1	3	1	3
H	Independencia 2	1	1	←	2	1	1	2	1	3	2	3

(9) Outline of each terminal

1) Terminal A: Icoaraci (see Figure 14.5-6)

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.

2) Terminal B: Tapana (see Figure 14.5-7)

Tapana Terminal is located at the irregular crossing of Rod. A. Montenegro, Avenida Mario Covas and Str. do Tapana. The bus entrance should be directly connected to the exit of Avenida Mario Covas.

The adjacent area might be reserved for car parking for “park-and-ride.”

3) Terminal C: Mangueirao (see Figure 14.5-8)

The site is in the vast open area surrounding Mangueirao Stadium. From the viewpoint of efficient land use and the distance to the entrance of the stadium, the area next to the existing planetarium was selected. There is plenty of room for extension. The adjacent area might be reserved for car parking for “park-and-ride.” It is more advantageous than Tapana Terminal because the area has been already prepared.

The layout of the bus terminal is typical in this project. The trunk bus will run along the boundary and will use the outside berth parking along the boundary. The feeder bus will use the inside berth, making a U-turn at the end of the site.

The typical integrated terminals have the entrance and the exit of buses at the side of the site. The direction is set in reverse compared to the normal “keep to the right” traffic, for smooth movement of the trunk bus.

4) Terminal D: Coqueiro (see Figure 14.5-9)

The Coqueiro terminal would be connected at the crossing of Av. Mario Covas and Av. Tres Coracoes. The entrance and the exit should be placed with the normal “keep to the right” direction in the center of the site.

One alternative plan is grade separation of the traffic of buses and the passengers. The passenger building (see Figure 14.5-14) with passage should be made on the second floor level with stairs to the sidewalk and the platforms. A pedestrian overpass could be attached to the opposite side of Av. Mario Covas.

Another plan is an access road to the site recessed from Av. Mario Covas, avoiding the existing electricity poles. The centerline of the access road should be in line with that of Av. Tres Coracoes. The pedestrian access would be located on the north.

The trunk buses should cross the pedestrian crossing for the passengers before reaching the berth and after leaving the berth, while the feeder buses would not cross one another.

Considering better feasibility, the latter was adopted in this study.

5) Terminal E: Aguas Lindas (see Figure 14.5-10)

The site is the existing private bus terminal. The present buildings seen will be demolished and the new terminal will be constructed.

As the width of the site is limited, the one-platform type was adopted. It has the advantage that the buses will not cross the pedestrian way, but has disadvantage that the walking distance is longer to the recessed berths.

Just in case the land is not available, the open area in the vicinity would be used.

6) Terminal F: Marituba (see Figure 14.5-11)

Marituba Terminal has many feeder bus services and the number of passengers will be the largest among the integrated terminals. The site would be in the ex-factory site, which is large enough to accommodate the future long-distance terminal and car parking for "park-and-ride." The connection to the long distance terminal would be made on the completion.

7) Terminal G: Independencia 1 (see Figure 14.5-12)

The site for Terminal G is in a low-utilized private land at the corner of Av. Mario Covas and Av. Independencia. The fronting Av. Independencia is an unpaved two-lane road now. Several houses along the road should be relocated. Earth filling might be required according to topography and soil conditions.

This bus terminal is a typical small type with four trunk bus berths and six feeder bus berths in total.

8) Terminal H: Independencia 2 (see Figure 14.5-13)

The site for Terminal H is in an unused area near Casa do Governador do Para (Para Governor's House). The fronting Av. Independencia has not been constructed yet and the site is not accessible at present.

This bus terminal is the same as Terminal G.