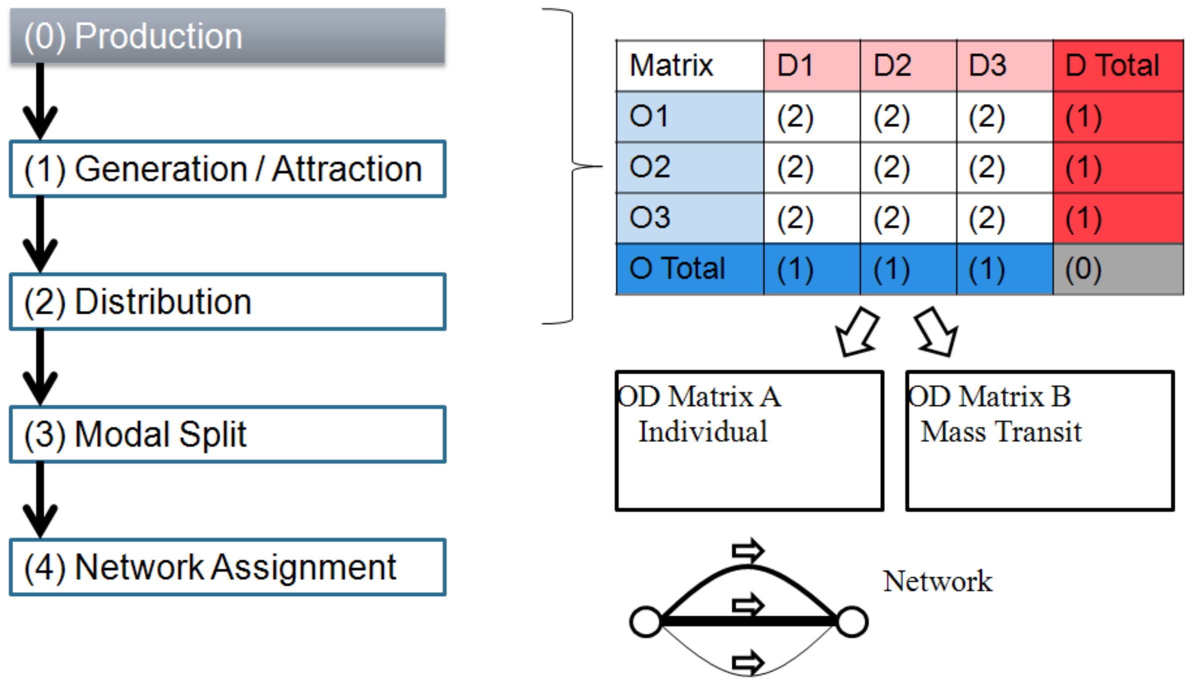
## 3.3 TRAFFIC DEMAND FORECAST

### 3.3.1 Context of Traffic Demand Forecast

The main objective of this project with regard to the estimation of traffic demand by mode is essentially to quantify the benefits of ITS implementation. The traffic demand analysis has the purpose of providing a "big picture" of the current and future traffic volumes in the network. It should be noted that the traffic demand process under urban transport plan (*Plano Diretor de Transporte Urbano*: PDTU) is much more detailed since it has a different purpose, namely, to understand the traffic patterns of each region and draw guidelines for growth and development.

A conventional four-step traffic demand modelling was conducted in this project which is briefly described in Figure 3-50 below.




Source: JICA Study Team

**Figure 3-50 Methodology for Macro-scale Analysis: Four-step Method**

Where:

(0) Production: Total number of trips in the whole area;
(1) Generation/Attraction: Number of trips generated from or attracted to each zone;
(2) Distribution: Number of trips for each pair of zones = OD Matrix;
(3) Modal Split: Number of trips of each mode for each pair of zones; and
(4) Network Assignment: Demand on each link of the network.

### 3.3.2 Review of Existing Transport Master Plans

As discussed in Section 3.1, the following three main studies were considered as the starting point for the supplementary traffic demand forecast conducted in this Study:

- PDTU/RMRJ 2005 (Current RMRJ Transport Master Plan);
- PDTU/RMRJ 2011 (Ongoing update of the 2005 Transport Master Plan); and
- Rio 2016 Transport Strategy (Strategic Plan for 2016 Olympic Games by the *Secretaria Municipal de Transportes*: SMTR).

These three studies are further summarized in the context of traffic demand forecast as follows:

(1) PDTU/RMRJ 2005

- 20 municipalities included as part of the RMRJ
- 485 traffic analysis zones (TAZ)
  - 342 in the city of Rio de Janeiro, 143 in the RMRJ
- 34,000 households surveyed
- Travel demand forecast method: four-step model
  - Trip generation: home-based work (40.2%), home-based school (33.1%), home-based other (23.4%) and non-home based (3.2%)
  - Trip distribution.: gravity model
  - Modal split: logit model
  - Traffic assignment: not clear
- Target years: 2008 and 2013
- Based on 1991 and 2000 Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*: IBGE) Census Data
- Socioeconomic data used: population, employment, school enrollment, motorization rate, average income
- Population growth of 1.5%/year and employment growth of 1.84%/year in the RMRJ

(2) PDTU/RMRJ 2011 (Summary)

- Target years: 2016 and 2021
- Refined 2003 PDTU TAZs: 730
- Over 100,000 surveys – still ongoing
- Origin-destination (OD) data not available - data analysis expected to be concluded in early 2013
- Model to be developed using EMME 2
- Master plan will suggest transit-oriented strategies as priority for future growth of RMRJ

(3) Rio 2016 Transport Strategy

- Used the base OD matrix of PDTU 2005 as starting point
- 547 TAZs
- Base year: 2011; Target year: 2016
- Conducted auxiliary traffic counts around RMRJ from 2009 to 2011
- Based on 2000 and 2010 IBGE Census Data
- Socioeconomic data used: population, employment, school enrollment, motorization rate, and average income
- Population growth of 1.01%/year and employment growth of 1.43%/year in RMRJ from 2011 to 2016
- Travel demand forecast method: not clear – reference to EMME Algorithm developed by Hans Spiess for OD balancing
- 10% growth on trips from 2011 to 2016
- 20% demand reduction (due to school vacation and other traffic measures) for 2016 Olympic Game scenarios

Table 3-11 below compares the key features of the three main studies described above.

**Table 3-11 Comparison of Existing Transport Master Plans**

| Data | PDTU 2005 | PDTU 2011 | SMTR Strategic Plan for 2016 Olympic Games |
|---|---|---|---|
| Number of TAZs | 485 | 730 | 547 |
| - Base Year<br>- Target Year | 2003<br>2008 and 2013 | 2012<br>2016 and 2021 | 2011<br>2016 |
| Population and Employment Data for projection | IBGE Census 1991<br>IBGE Census 2000 | IBGE Census 2000<br>IBGE Census 2010 | IBGE Census 2000<br>IBGE Census 2010 |
| Origin-Destination Matrices | Developed in 2003 | Ongoing surveys – not ready yet | Adjusted PDTU 2003 ODs to reflect Census 2010<br>Addition of 2010 Metro and Supervia ODs |
| Future Scenario | Trend<br>Induced | Trend<br>Induced | Trend<br>Olympic Demand |

Source: JICA Study Team

### 3.3.3 Methodology

(1) Methodology of Macroscopic Traffic Demand Forecast

From the review of the three main sources discussed in the previous section, the JICA Study Team found constraints on the availability of some data in the Rio 2016 Transport Strategy and PDTU 2011. These data were requested; however, they were neither available nor ready for replication and further analysis. In addition, given several discussions with the counterpart, the decentralization of a core business development center (downtown area) and creation of multiple sub-centers around the RMRJ have been acknowledged since 2003. The updated employment data and model validation were used to account for this change in the economic scenario.

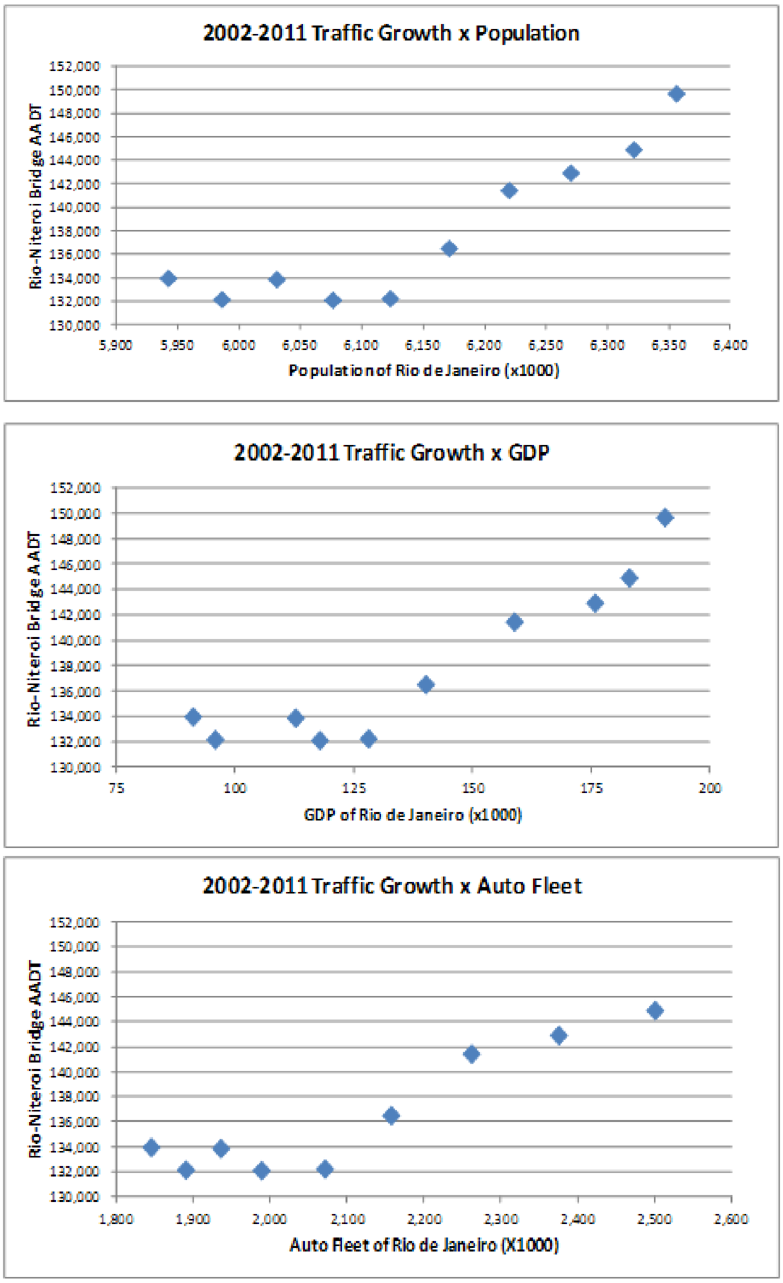
Based on the above, the 2003 base O-D matrix from PDTU 2005 was used as the basis for the traffic demand forecast. Initially, the team refined the PDTU 2005 TAZs from 485 to 547. The adopted base year was 2011 and the target years were 2016 and 2021. These items are described as follows:

(2) OD Assumptions

1) 2011 OD

For the 2011 OD calibration, the growth parameters (from the available 2003 OD) were based on population, GDP, and fleet historical data as shown in Figure 3-51 below. The basic assumptions for the 2011 base year are the following:

- Assumed same traffic growth pattern from 2003;
- Statistical models using population, GDP, and fleet data developed to estimate overall growth from 2003 to 2011 (see the table in the next page);
- Existing traffic counts from CET-Rio and SMTR used to calibrate and validate 2011 base OD; and
- Traffic growth of 42% for auto and 8% for public transport from 2003 to 2011 after validation.




Sources: IBGE, Detran, PDTU 2005, and IMF

**Figure 3-51 Data Used to Estimate Gross Traffic Growth from 2003 to 2011**

For trip generation, distribution, modal split and assignment, the following assumptions are used for the 2011 base year:

- Bus Average Occupancy: 34 passengers/bus (SMTR Study)
- Van Average Occupancy: 5 passengers/van (SMTR Study)
- Auto Average Occupancy: 1.5 passengers/car (IPEA)
- Traffic Percentage (CET-Rio Data):
    - 6.5% of daily traffic during evening peak hour and
    - 5.9% during morning peak hour
- Assumed Capacity (HCM 2000 and Florida Dept of Transp. Quality/Level of Service 2009 Handbook):
    - Freeway: 2100 pcu/hour/lane
    - Major Arterial: 1800 pcu/hour/lane
    - Minor Arterial: 1000 pcu/hour/lane
- Modal Split (PDTU 2005):
    - Auto: 26.3%
    - Bus: 64.9%
    - Train: 2.4%
    - Others (school bus, boat, cable tram): 3.6%

2) 2016 OD

- Developed from calibrated/validated 2011 base OD;
- Linear growth from socioeconomic data forecast (population, GDP, and fleet) (sources: IBGE, Detran and IMF);
- Two scenarios being developed: Regular traffic and Olympic Games (see Table 3-12 below); and
- Overall traffic growth of 4.9% from 2011 to 2016.

**Table 3-12 Analysis Periods for Olympic Games Scenario**

| Day/Critical Hour | Critical Zone | Critical Demand | Daily Demand for Olympic Games |
|---|---|---|---|
| 3rd day/<br>18:00 (Evening Peak) | Barra | 45,418 | 83,627 |
| 6th day/<br>22:00 (Off-peak) | Barra | 45,877 | 104,495 |
| 9th day/<br>8:00 (Morning Peak) | Copacabana | 14,316 | 170,231 |
| 10th day/<br>21:00 (Off-peak) | Maracana | 81,202 | 303,741 |
| 11th day/<br>16:00 (Off-peak) | Maracana<br>Deodoro | 66,378<br>15,180 | 102,495 |

Source: SMTR Strategic Plan for 2016 Olympic Games

3) 2021 OD

- Developed from calibrated/validated 2011 base OD;
- Linear growth from socioeconomic data forecast (population, GDP, and fleet) (sources: IBGE, Detran and IMF); and
- Overall traffic growth of 10.9% from 2011 to 2021.

4) Comparison of Base OD

A comparison between the OD of the base year (2011) and the ODs of the target years (2016 and 2021) is shown in Table 3-13 below.

**Table 3-13 OD Summary Results**

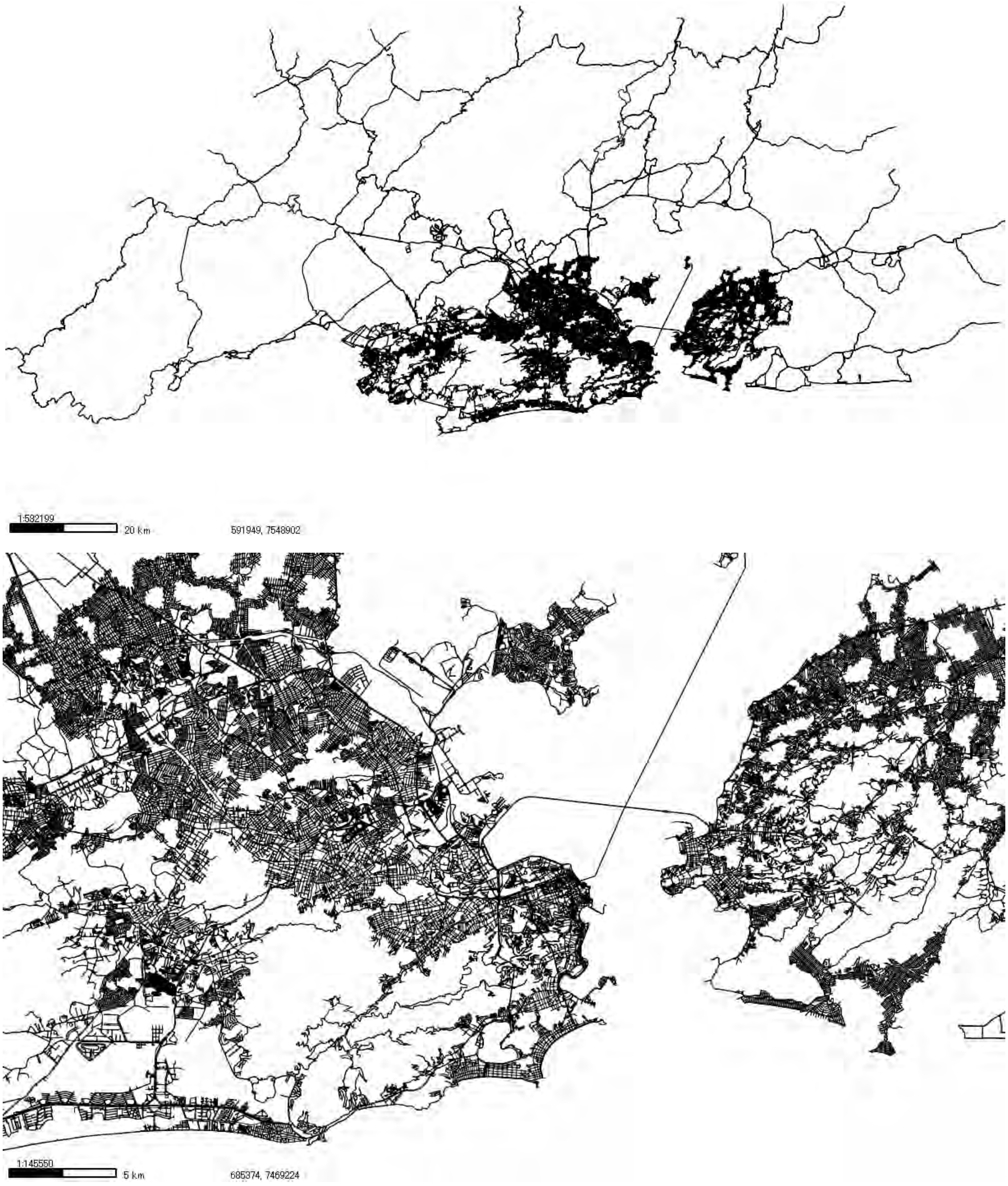
| | **2003 OD (PDTU 2005)** | **2011 Base OD** | **2016 OD** | **2021 OD** |
|---|---|---|---|---|
| Number of TAZs | 485 | 547 | 547 | 547 |
| Traffic Growth | 12.53 million (base number) | 42% for auto<br>8% for bus<br>(from 2003) | 4.9%<br>(from 2011) | 10.9%<br>(from 2011) |
| RMRJ Population | 11.16 million | 11.95 million | 12.40 million | 12.96 million |
| Population Growth | N/A | 7.1 %<br>(from 2003) | 3.8%<br>(from 2011) | 8.5%<br>(from 2011) |

Source: JICA Study Team

(3) Network Data

1) Existing Network

The existing network for the base year (2011) was built based on the digital road map product made by a third party map vendor, i.e., Navteq. The network for traffic modeling covers the RMRJ. In the municipalities of Rio de Janeiro and Niteroi, local roads are included but in the other municipalities in RMRJ, only arterial roads are included in the modeling network (see Figure 3-52 below). The Navteq data was updated into the 2011 network by the JICA Study Team in terms of network and number of lanes.




Source: JICA Study Team

**Figure 3-52 Existing Network for Traffic Modeling**

2) Future Network

The networks for the target years of 2016 and 2021 were built based on the concept of the PDTU 2011 updated study, Rio 2016 Transport Strategy's upgraded plan for the Olympic Games, and the planned road network shown on the road map of the Department of Highways (*Departamento de Estradas de Rodagem*: DER) in Figure 3-55.

As for the 2016 network, the minimum development assumed in the PDTU 2011's updated study and the development in the Rio 2016 Transport Strategy's upgraded plan were considered. Moreover, it was assumed that the planned bus rapid transit (BRT) lines using the existing road network did not affect the network's capacity.

As for the 2021 network, the planned roads in the DER's map were added. No additional network from the PDTU 2011 updated study was considered because only public transport lines were added to the 2016 plan's minimum network. Figures 3-53 and 2-54 below illustrate the 2016 and 2021 networks, respectively.


Source: Provided by the PDTU 2011 Update Study Team

**Figure 3-53 Minimum Network in 2016**


Source: Provided by the PDTU 2011 Update Study Team

**Figure 3-54 Proposed Network in 2021**


Source: DER-RJ Road Map

**Figure 3-55 Planned Network in the DER's Map**

[Upgrade for the Olympic Games Scenario]

- BRT TransOlimpica: New motorway and BRT corridor
- BRT TransBrasil, TransOeste, TransCarioca: BRT corridor (no influence)
- Metro Extension (Lines 1 and 4) (no influence)
- Av. Abelardo Bueno (10 lanes)
- Av. Salvador Allende (10 lanes)
- Av. Ayrton Senna (12 lanes)

Source: Transport Strategic Plan for the Rio 2016 Olympic and Paralympic Games

3) Traffic Measures for the Olympic Games

In the 2016 network, it was necessary to add the Olympic Games traffic measures in order to analyze the Olympic Games scenario. The traffic measure called Olympic Lanes, based on the Rio 2016 Transport Strategy Plan, is a set of dedicated lanes for the Olympic Games family transport. Therefore, the number of regular lanes was reduced in the traffic modeling.


Source: Rio 2016 Transport Strategy Plan

**Figure 3-56 Olympic Lanes**

4) Road Capacity

Navteq's data has road functional class, which defines a hierarchical network used to determine a logical and efficient route for a traveler.

[Functional Class for Navteq Data]

- ***Functional Class*** = 1 roads allow for high volume, maximum speed traffic movement between and through major metropolitan areas.

  ***Functional Class*** = 1 is applied to roads with very few, if any, speed changes. Access to the road is usually controlled.

- ***Functional Class*** = 2 roads are used to channel traffic to ***Functional Class*** = 1 roads for travel between and through cities in the shortest amount of time.
- ***Functional Class*** = 2 is applied to roads with very few, if any speed changes that allow for high volume, high speed traffic movement.
- ***Functional Class*** = 3 is applied to roads which interconnect ***Functional Class*** = 2 roads and provide a high volume of traffic movement at a lower level of mobility than ***Functional Class*** = 2 roads.
- ***Functional Class*** = 4 is applied to roads which provide for a high volume of traffic movement at moderate speeds between neighbourhoods. These roads connect with higher functional class roads to collect and distribute traffic between neighbourhoods.
- ***Functional Class*** = 5 is applied to roads whose volume and traffic movement are below the level of any functional class. In addition, walkways, truck only roads, bus only roads, and emergency vehicle only roads receive ***Functional Class*** = 5.

In this study, referring to the Highway Capacity Manual and functional road class from the Navteq Data, the capacity of each road was defined as shown in Table 3-14 below. In addition, the maximum speed and width of lane were also defined in the same table.

**Table 3-14 Setting of Road Capacity**

| Function Class (Navteq Data) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Road Type (Modeling Software) | Freeway | Arterial | Road | Street | Urban Road |
| Max. Speed (km/h) | 120 | 80 | 60 | 50 | 40 |
| Width (m) | 3.5 | 3 | 3 | 3 | 3 |
| Capacity (PCU / hour) | 2,100 | 1,800 | 1,000 | 900 | 800 |

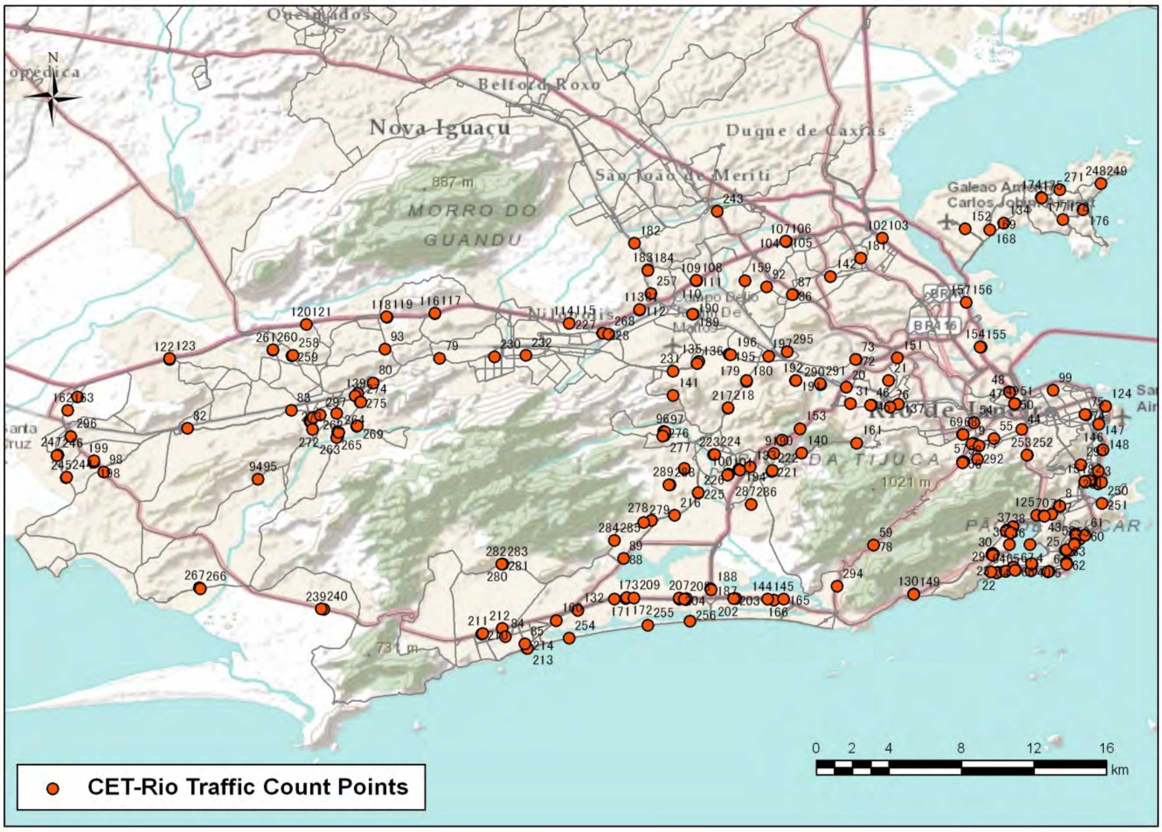
Source: JICA Study Team

### 3.3.4 Validation of Current Traffic Condition and Analysis of Future Data

The validation data used hourly traffic count in May 2011 provided by CET-Rio. The analysis periods are the following:

- Morning Peak (7:00 ~ 9:00 a.m.)
- Evening Peak (5:00 ~ 6:00 p.m.)
- Olympic Peak (4:00 p.m. and 9:00 p.m.)
- Day (24 hours)

For the validation process, the 2011 OD was adjusted using the Furness method. Then, the future OD data (2016 and 2021) were prepared by applying the growth rates described previously.




Source: JICA Study Team

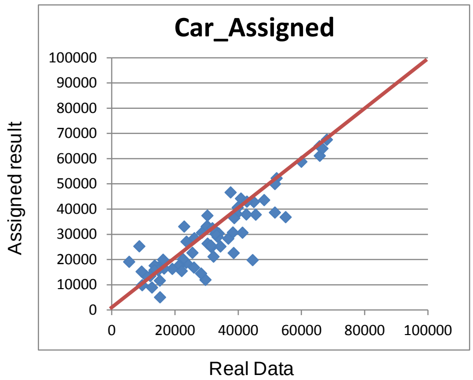
**Figure 3-57 CET-Rio Traffic Count Points Map**

(1) Validation Result

The assignment accuracy was evaluated by using the day (24 hours) assignment results. The evaluation was conducted under two cases, namely, “arterial road” and “multilane arterial road”. Based on the results shown in Figures 3-58 and 3-59 below, the “multilane arterial road” case was adopted.

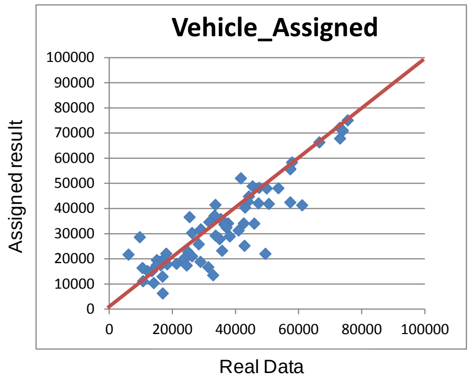
[Arterial Road: Functional Road Class 1 and 2 (68 points)]

***Car***




| R2 | 0.89 |
|---|---|
| % RMS | 23% |

***PCU (Car + 2 * Bus)***



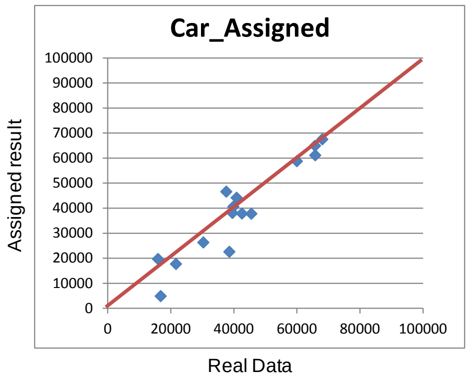

| R2 | 0.89 |
|---|---|
| % RMS | 23% |

Source: JICA Study Team

**Figure 3-58 Assignment Accuracy in “Arterial Road” Case**

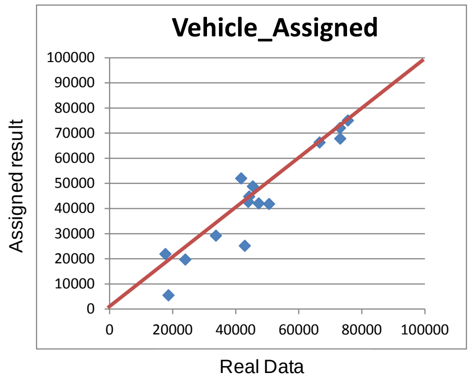
[Multilane Arterial Road: Functional Road Class 1 and 2 and Number of Lanes: 4 (15 points)]

***Car***




| R2 | 0.94 |
|---|---|
| % RMS | 16% |

***PCU (Car + 2 * Bus)***




| R2 | 0.94 |
|---|---|
| % RMS | 14% |

Source: JICA Study Team

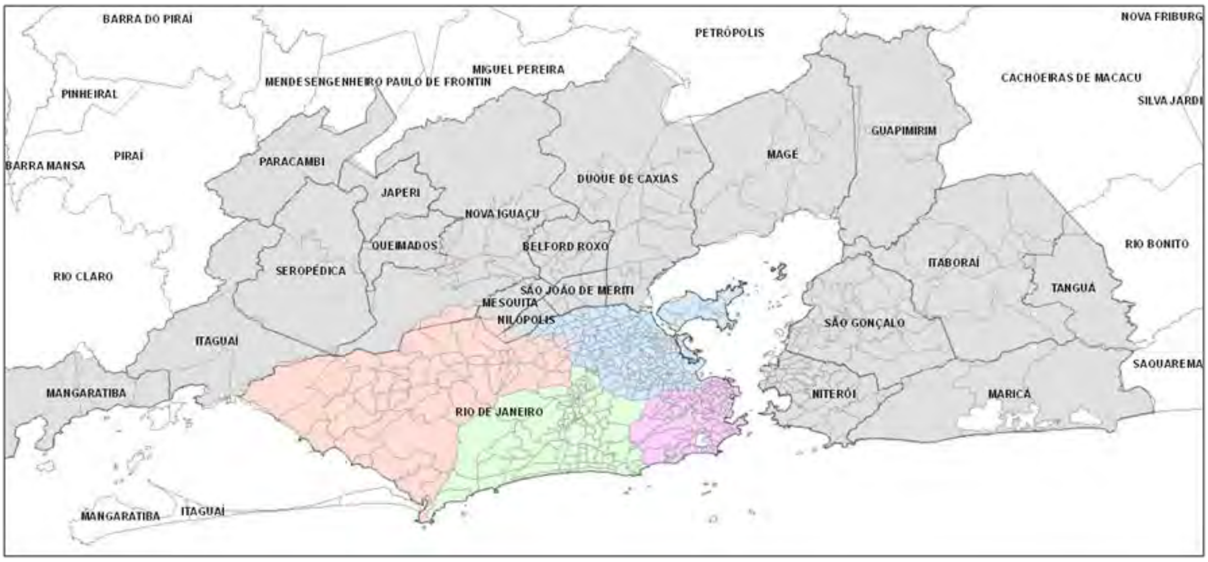
**Figure 3-59 Assignment Accuracy in “Multilane Arterial Road” Case**

(2) Analysis of OD Data

The OD data used in the traffic modeling is presented in this section.

1) Zone Map

The zone map for the OD data is shown in Figure 3-60 below.



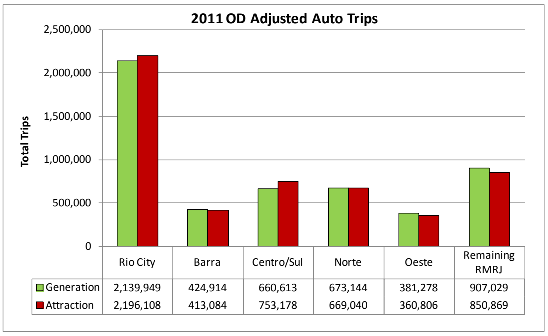

Source: JICA Study Team

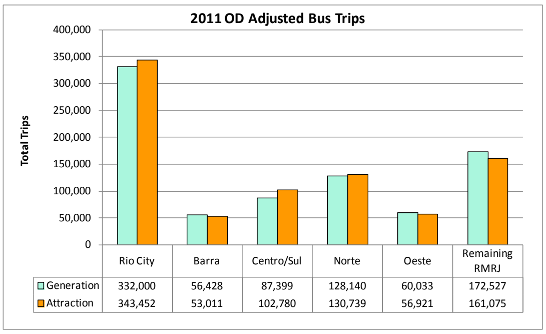
**Figure 3-60 Zone Map**

2) Total Trips

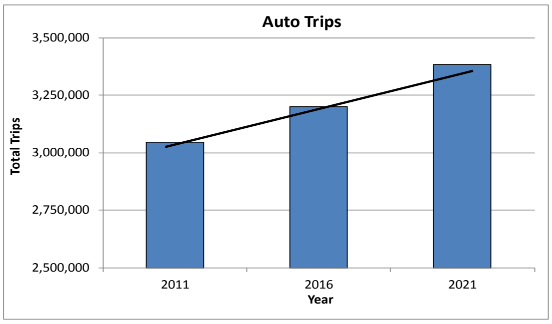
The total trips per area and mode (auto and bus) are shown in Figure 3-61 below.

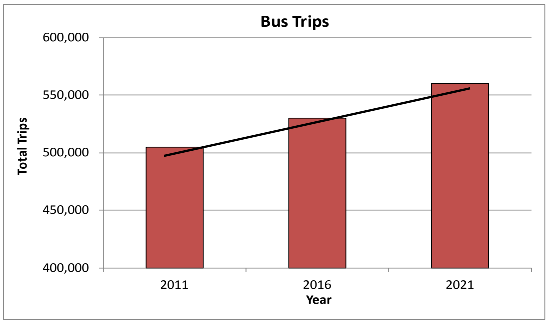
[2011 OD Adjusted]




[Comparison of 2011, 2016 and 2021]



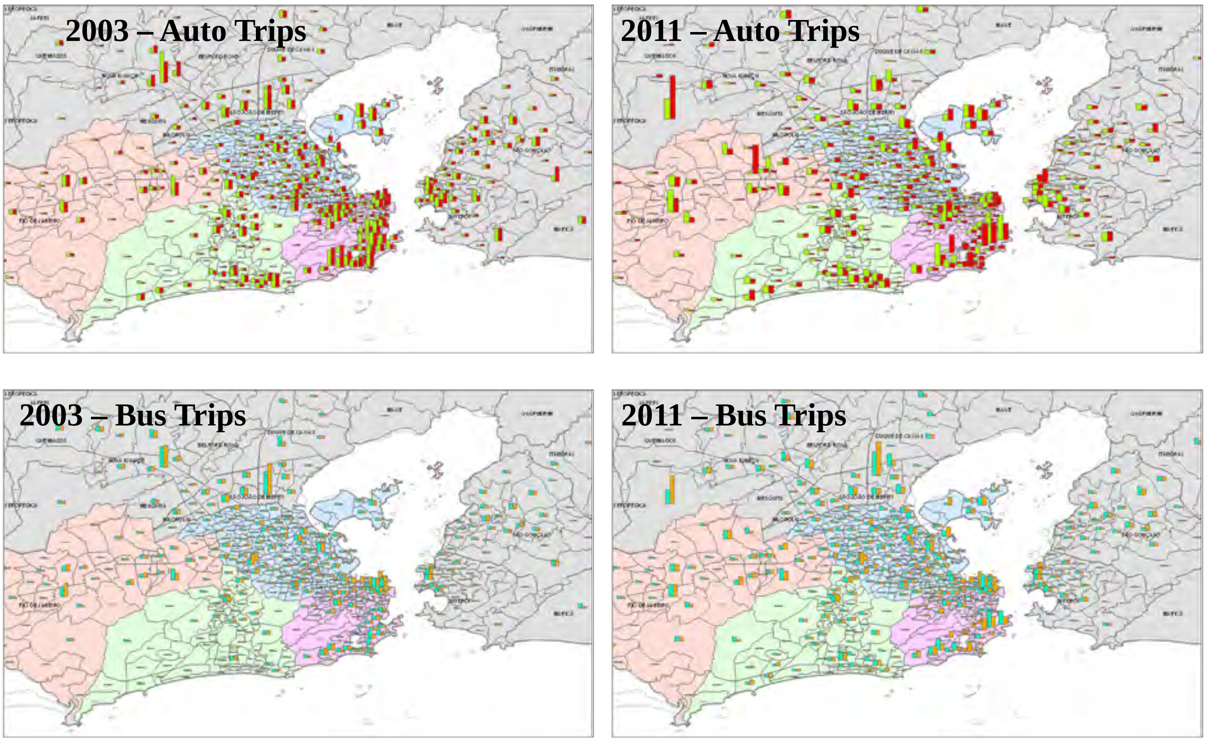

Source: JICA Study Team

**Figure 3-61 Total Trips**

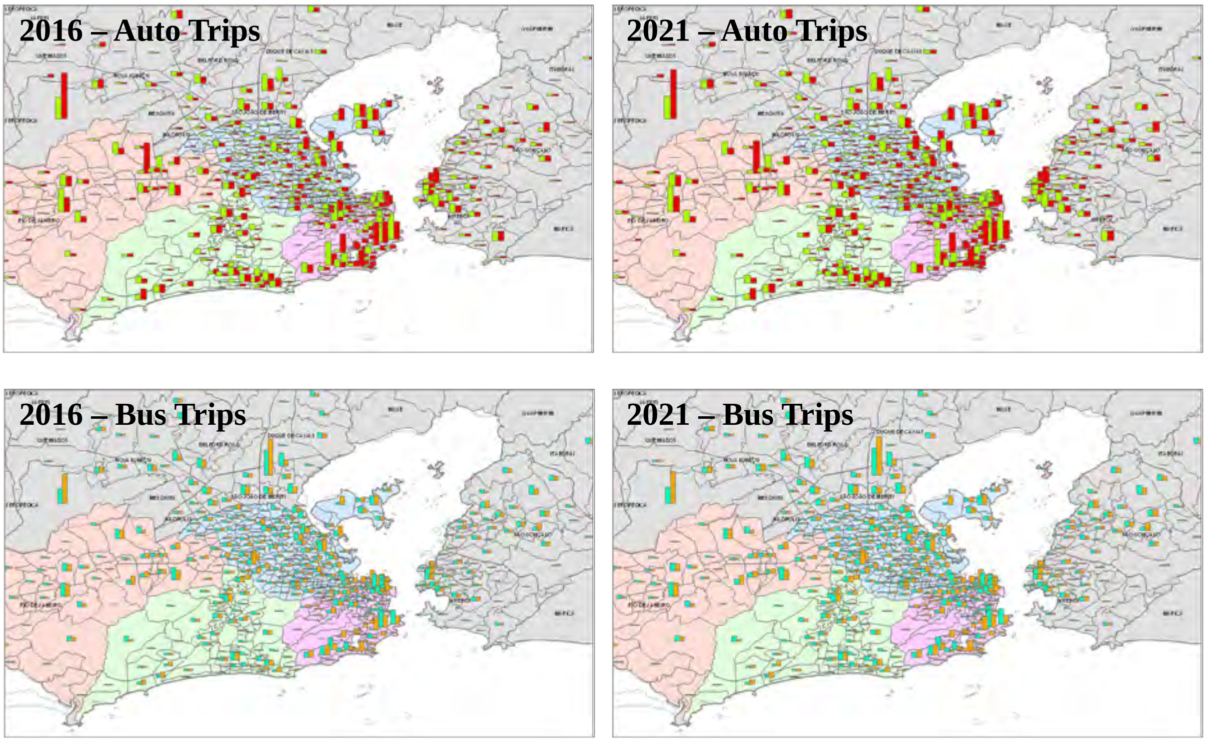
3) Distribution

The OD distribution data is shown in Figure 3-62 below.

[2003 and 2011 OD Adjusted]




[Future OD]




Source: JICA Study Team

**Figure 3-62 Distribution of OD Data**

4) Olympic Games OD

From the Olympic Games demand database provided in the Rio 2016 Transport Strategy, the critical days and volume were clarified as discussed below.

[Critical Days during the Olympic Games]

As a result of the spectators demand analysis for each venue, the critical days and time of the public demand during the Olympic Games period were identified. Table 3-15 below shows the results.

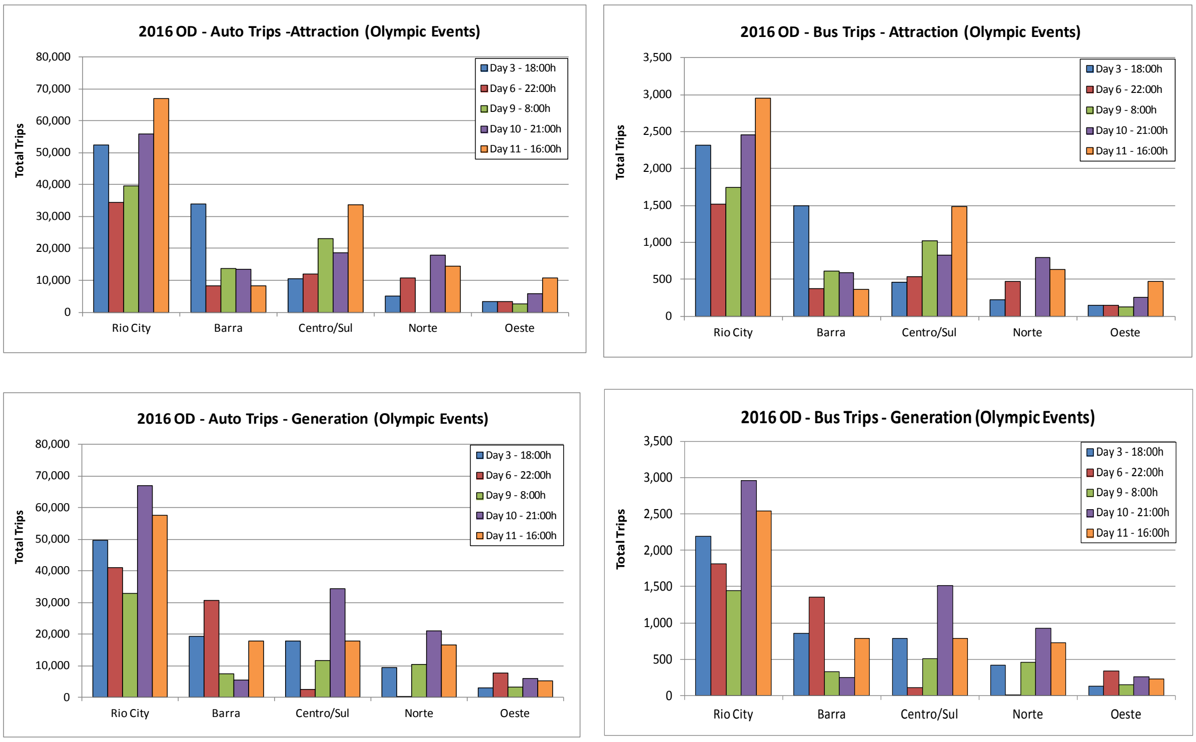
[Total Trips during Critical Days]

As a result of the spectators demand analysis during critical days, “3rd day/18:00”, “9th day/8:00”, and “11th day/16:00” were identified as the critical times.

**Table 3-15 OD Summary Results**

| Day/Critical Hour | Critical Zone | Critical Demand | Daily Demand for Olympic Games |
|---|---|---|---|
| 3rd day/<br>18:00 (PM Peak) | Barra | 45,418 | 83,627 |
| 6th day/<br>22:00 (Off Peak) | Barra | 45,877 | 104,495 |
| 9th day/<br>8:00 (AM Peak) | Copacabana | 14,316 | 170,231 |
| 10th day/<br>21:00 (Off Peak) | Maracana | 81,202 | 303,741 |
| 11th day/<br>16:00 (Off Peak) | Maracana<br>Deodoro | 66,378<br>15,180 | 102,495 |

Source: JICA Study Team




Source: JICA Study Team

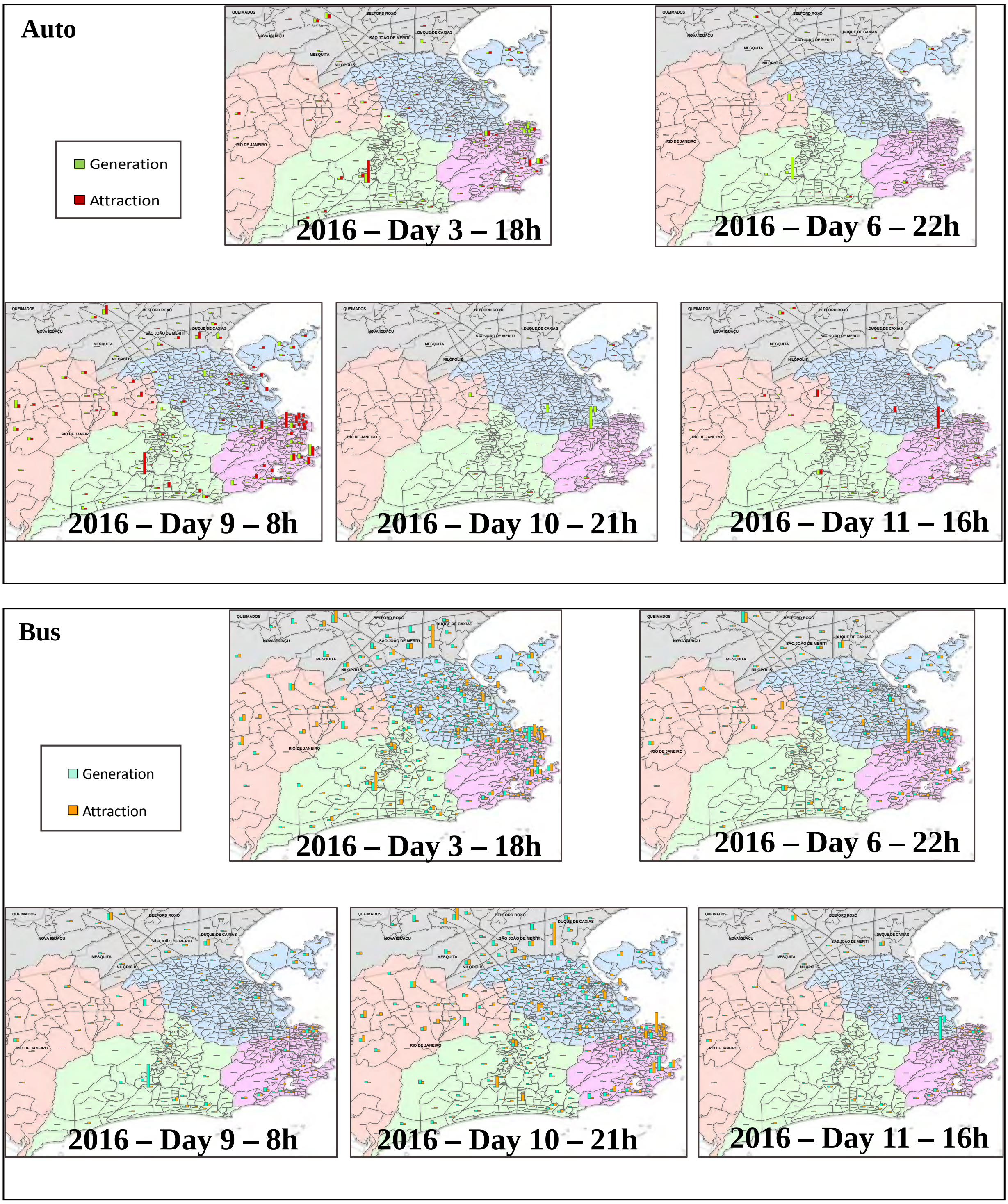
**Figure 3-63 Spectators Demand during Critical Days**


Source: JICA Study Team

**Figure 3-64 Spectators Demand + Background Demand during Critical Days**

[Distribution during Critical Times]

Figure 3-65 shows the distribution of spectators demand during critical times. The Centro and Barra areas are expected to have high numbers of trips during the Olympic Games.

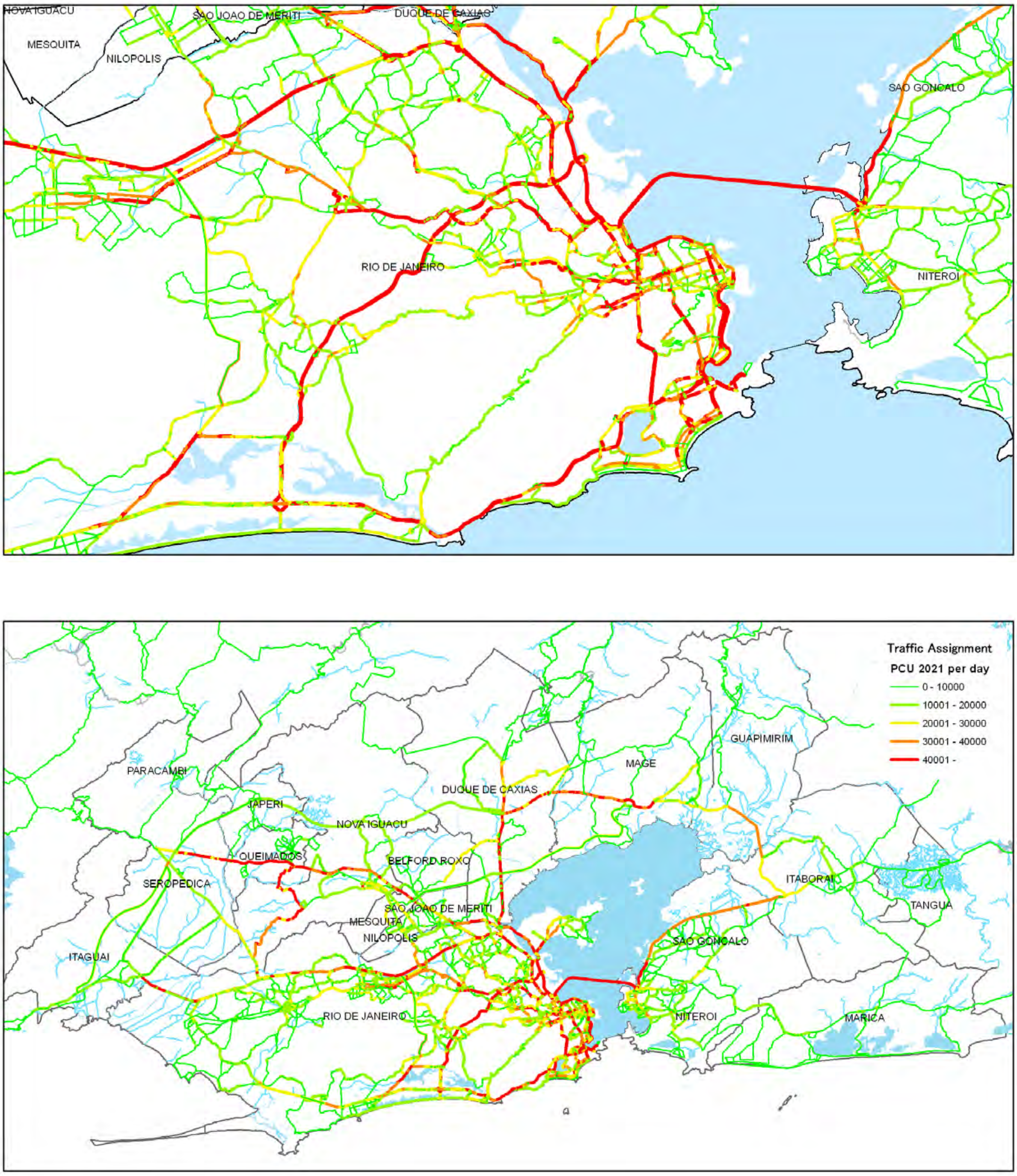



Source: JICA Study Team

**Figure 3-65 Distribution of Spectators Demand during Critical Days**

(3) Assignment Result of 2021 Traffic Condition

Figure 3-66 shows the assignment result of the 2021 day OD. The main routes seem to have more than 40,000 PCU per day per direction.




Source: JICA Study Team

**Figure 3-66 Assignment Result of 2021 Day OD**

### 3.3.5 Analysis of Future Traffic Condition

1) Assignment Cases

The basic analysis cases are shown in Table 3-16 below.

The target years are 2011, 2016, and 2021. The assignment periods are day and peak hours during morning and evening. In the Olympic Games scenario, assignment on the network with the Olympic Lanes and reduced demand strategies was conducted.

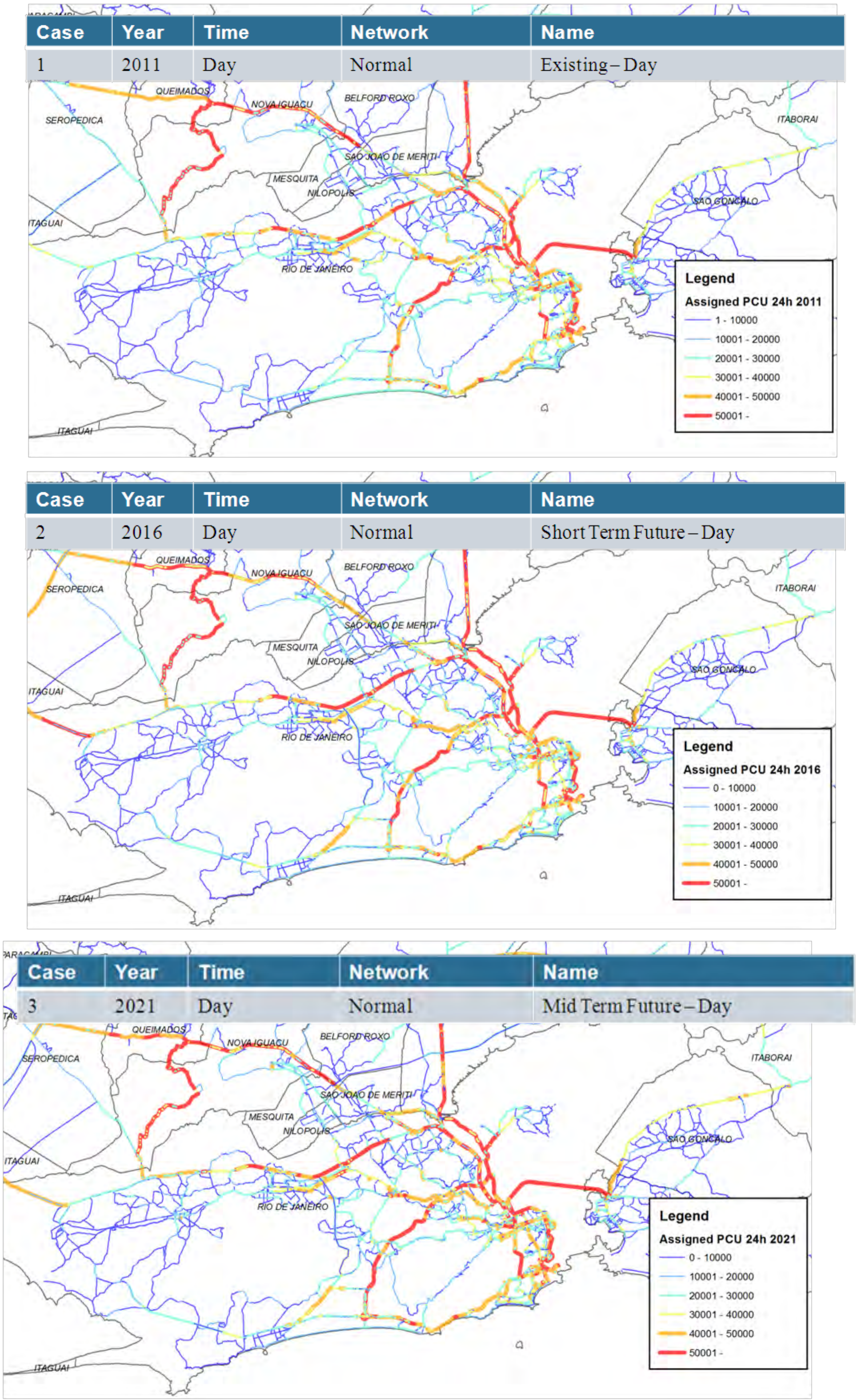
**Table 3-16 Basic Assignment Cases**

| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 1 | 2011 | Day | Normal | Existing – Day |
| 2 | 2016 | Day | Normal | Short Term Future – Day |
| 3 | 2021 | Day | Normal | Mid Term Future – Day |
| 4 | 2011 | 8 AM | Normal | Existing – Morning |
| 5 | 2011 | 6 PM | Normal | Existing – Evening |
| 6 | 2016 | Day | Olympic Lanes | Olympic Normal – Day |

Source: JICA Study Team

2) Day Assignment Result

High traffic volume was observed in the central area and on radial roads in Rio de Janeiro.



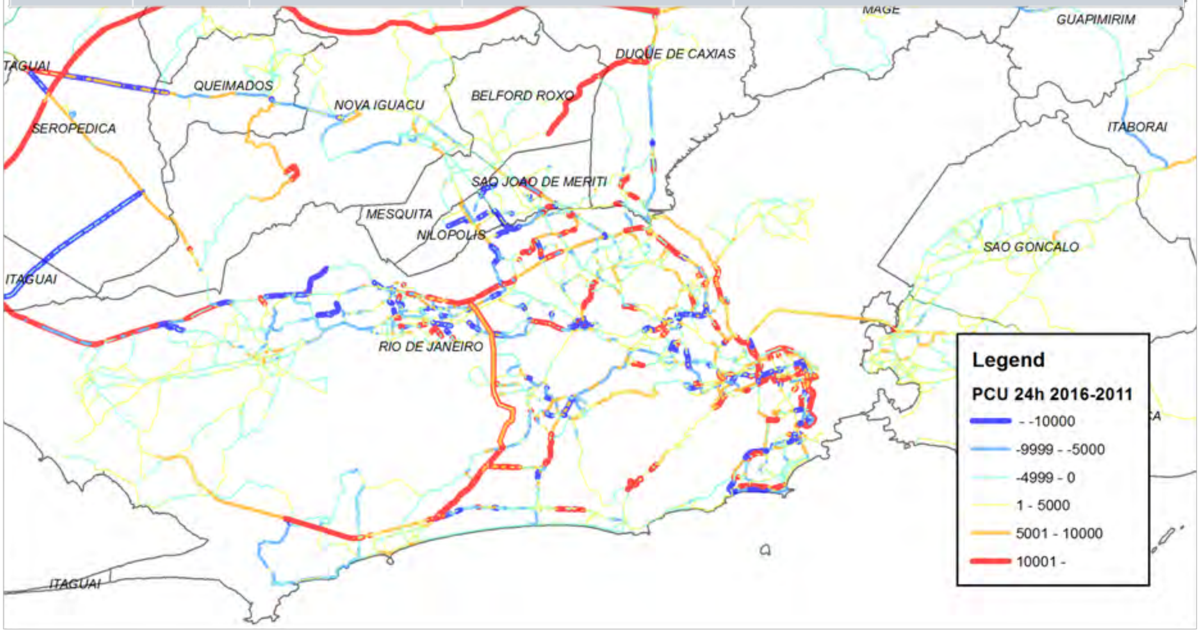

Source: JICA Study Team

**Figure 3-67 Assignment Result of Day OD**

3) Difference of Day Assignment Result

Because no specific new road construction is planned in the central area of Rio de Janeiro, the traffic volume in existing roads will increase in the future. This shows the need for traffic control measures such as ITS services in the near future.

| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 2 - 1 | 2016 | Day | Normal | Short Term Future – Day |




| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 3 - 1 | 2021 | Day | Normal | Mid Term Future – Day |

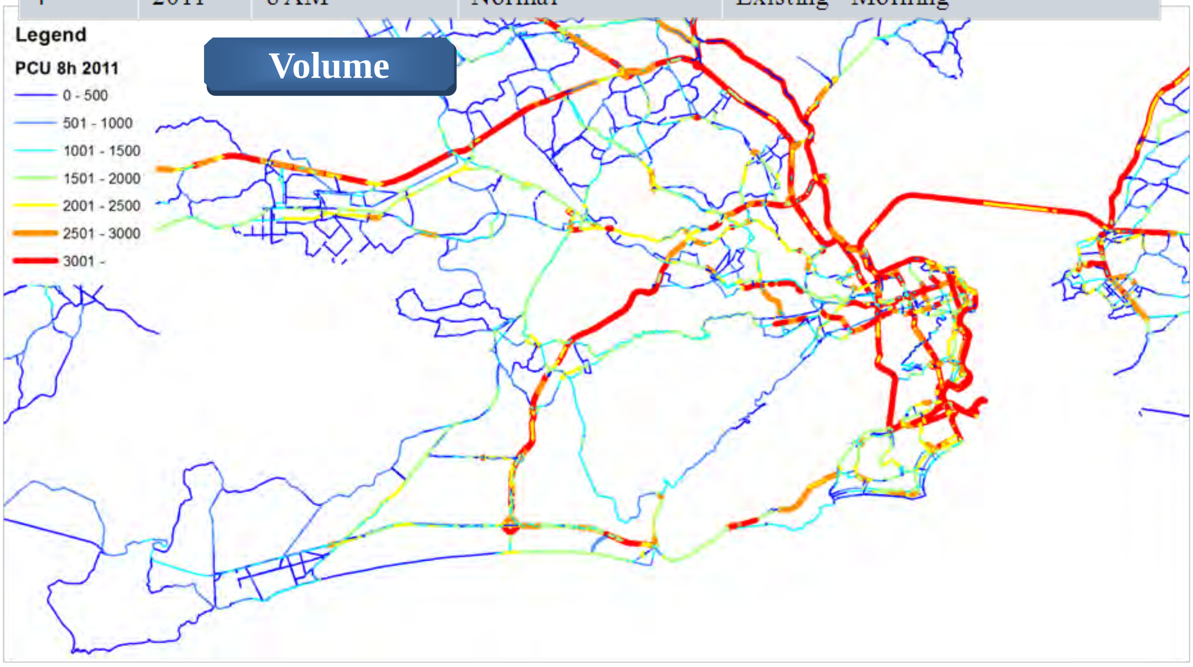

Source: JICA Study Team

**Figure 3-68 Difference of Assignment Result between Existing and Future**

4) Hourly Assignment Result

The 8 a.m. assignment result in Figure 3-69 shows that occupancy is high on the roads in the north area of Rio de Janeiro. Moreover, the roads in Niteroi are also congested.

| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 4 | 2011 | 8 AM | Normal | Existing－Morning |



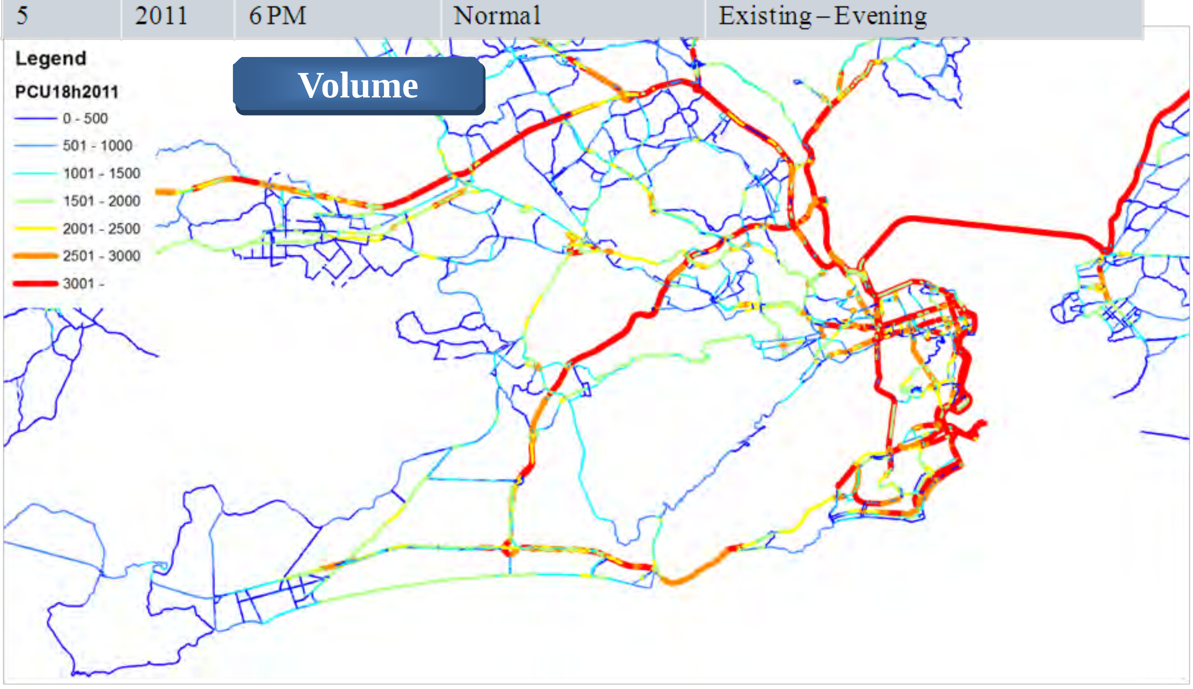

| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 4 | 2011 | 8 AM | Normal | Existing－Morning |


Source: JICA Study Team

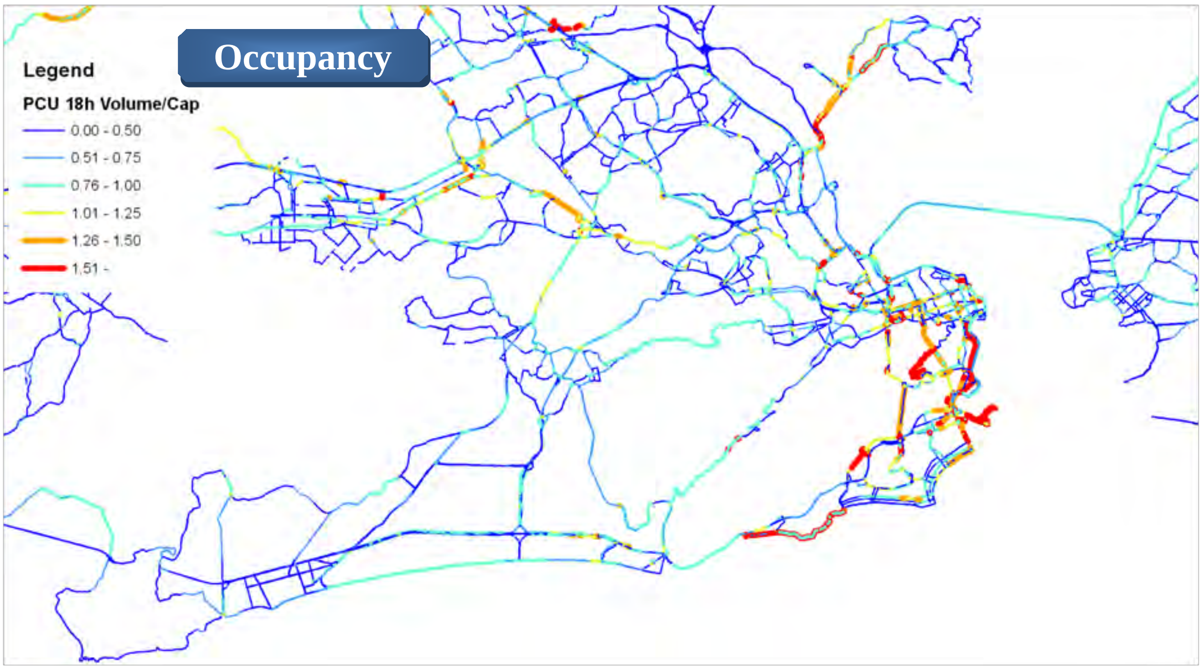
**Figure 3-69 Assignment Result of 8 a.m. OD**

The 6 p.m. assignment result in Figure 3-70 shows that occupancy is high on the roads in the south area of Rio de Janeiro.

| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 5 | 2011 | 6 PM | Normal | Existing – Evening |




| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 5 | 2011 | 6 PM | Normal | Existing – Evening |



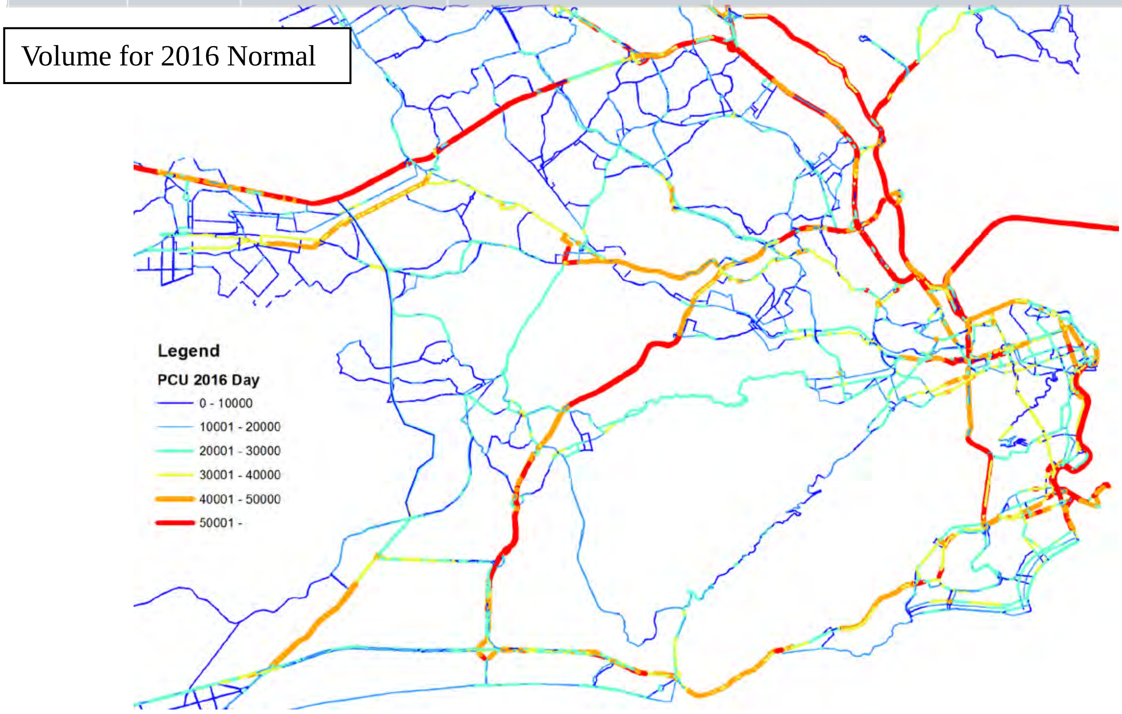

Source: JICA Study Team

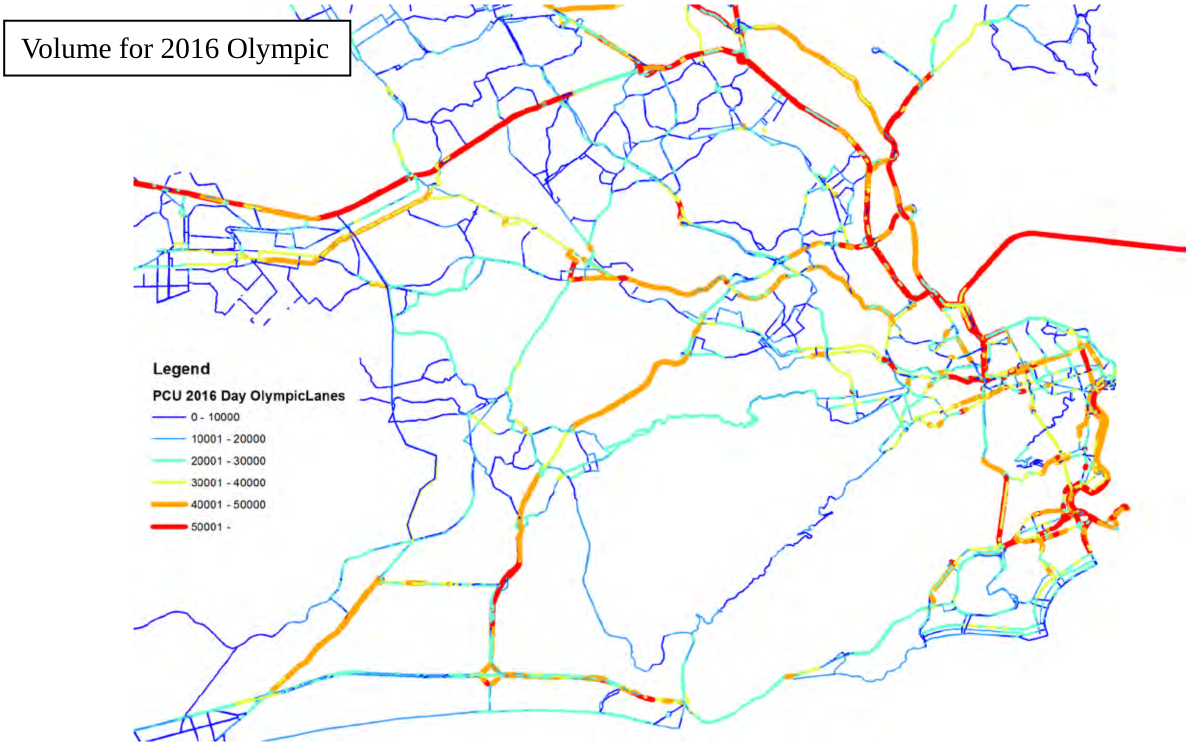
**Figure 3-70 Assignment Result of 6 p.m. OD**

5) Assignment Result of Olympic Games Scenario

The traffic volume along Olympic Lanes is decreased because of lane reduction. As a result, the other roads will have more traffic than under the normal scenario, as shown in Figure 3-71.

| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 6 | 2016 | Day | Olympic Lanes | Olympic Normal – Day |



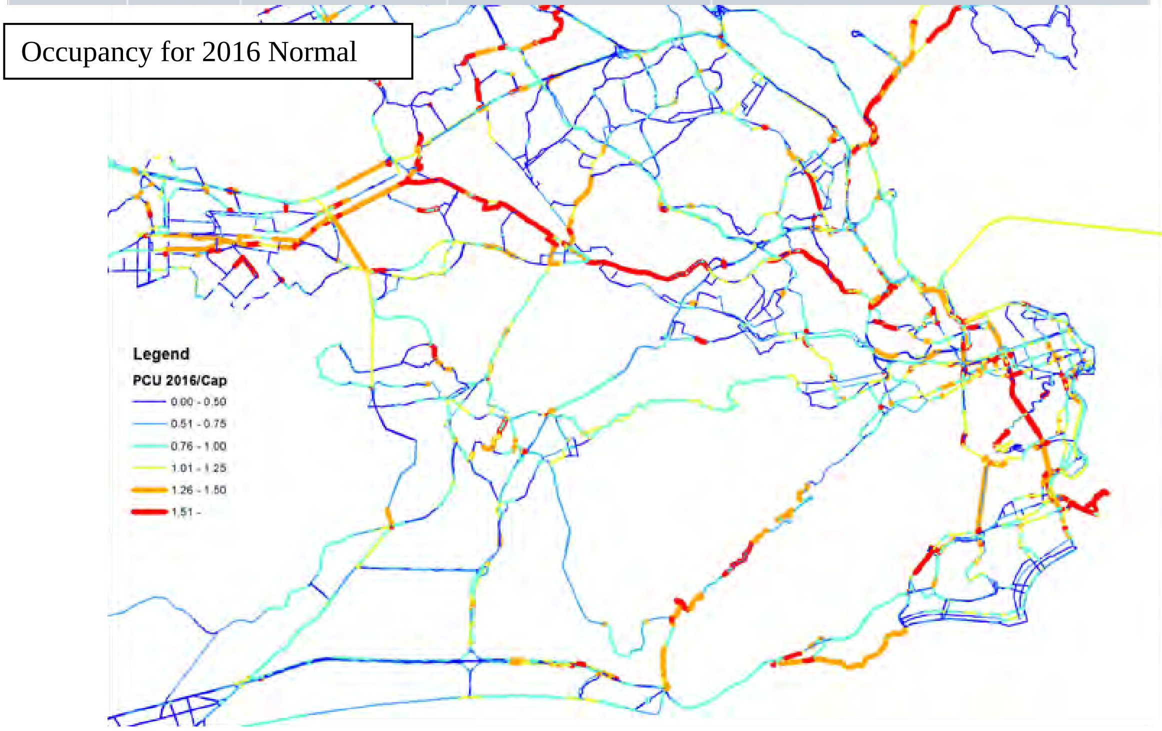



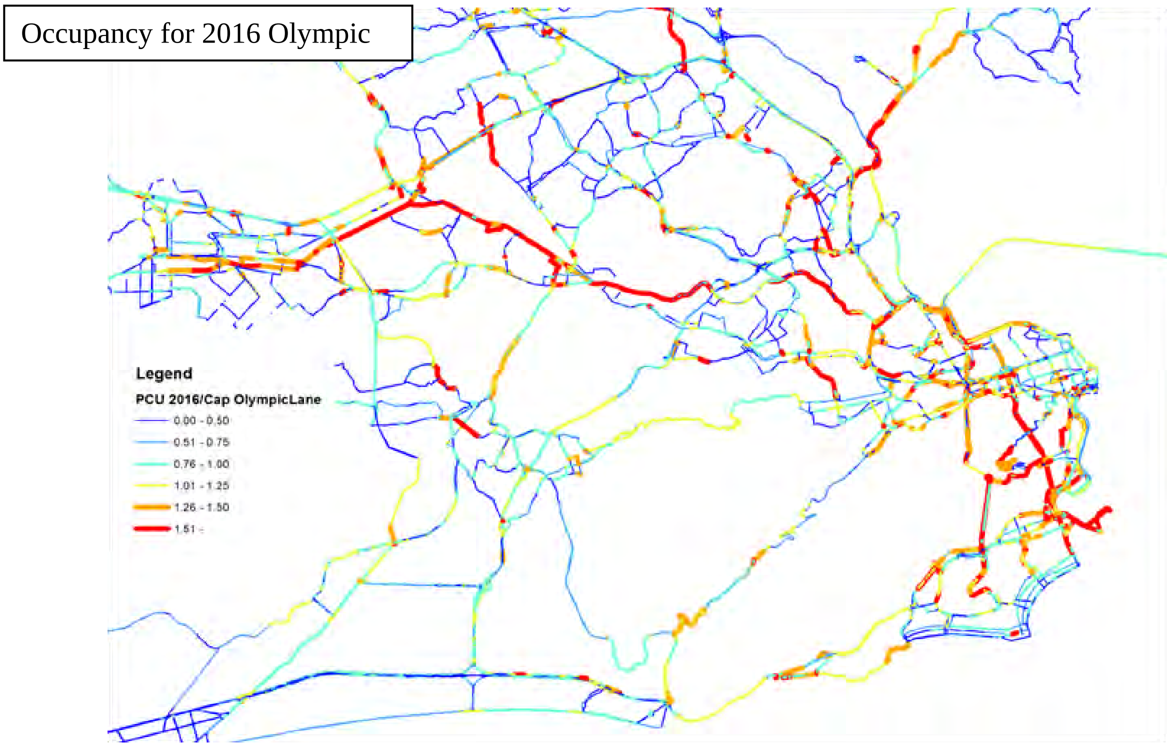

Source: JICA Study Team

**Figure 3-71 Assignment Result of Olympic Case (Volume)**

As shown in Figure 3-72, occupancy will increase in the entire network, especially in the central area of Rio de Janeiro where heavy congestion will be observed.

| Case | Year | Time | Network | Name |
|---|---|---|---|---|
| 6 | 2016 | Day | Olympic Lanes | Olympic Normal – Day |




Source: JICA Study Team

**Figure 3-72 Assignment Result of Olympic Case (Occupancy)**

### 3.3.6 Evaluation of ITS Installation

(1) Setting of Analysis Cases

The purpose of traffic modeling, which is an area-wide traffic analysis, is as follows:

- Transport/Traffic Analysis for Current and Future Situation
- Evaluation of ITS Menus

The evaluation of ITS menus is described hereafter.

1) Macroscale

Macroscale analysis provides the static impacts of transport policy and wide-area range simulation modeling. Accordingly, the ITS menus evaluated through macroscale modeling are as follows:

> Reversible Lane Management

Lane management is already implemented in Rio de Janeiro.

Hence, macroscopic economic impact shall be calculated in the static analysis.

> Electronic Road Pricing (ERP)

This aims at the reduction of travel cost by car in the whole target area.

The system costs shall be computed by summing up each component of ERP such as gantry, on-board unit (OBU), and monitoring center.

2) Mesoscale

Mesoscale analysis provides the dynamic impacts of transport policy and city-wide simulation modeling. Accordingly, the ITS menus evaluated through mesoscale modeling are as follows;

> Dynamic Traffic Information Provision to Every User

This aims at the reduction of travel cost by dynamic route search.

The total system cost shall be computed by the additional system cost of existing equipment and integration cost.

3) Microscale

Microscale analysis provides the dynamic impacts of transport policy and target area simulation modeling. Accordingly, the ITS menus evaluated through microscale modeling are as follows:

> Bus / BRT Signal Optimization

This aims at the reduction of waiting time or queue length.

The total system cost shall be computed by the additional system cost of existing equipment and integration cost.

> Electronic Toll Collection (ETC)

This aims at the reduction of waiting time at the toll gate.

The system cost shall be the additional system cost of existing equipment.

(2) Setting of Analysis Areas

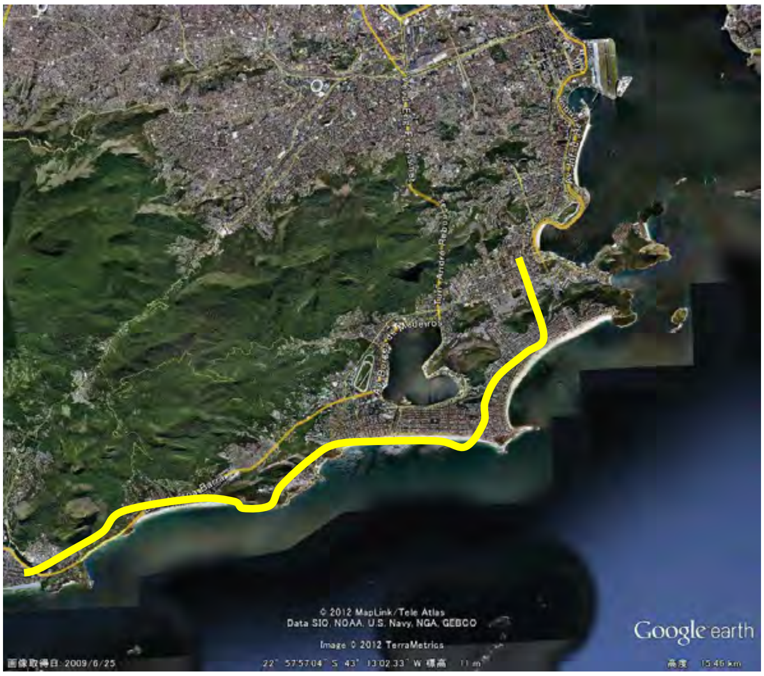
1) Reversible Lane Management

The main area for reversible lane analysis is the south region of Rio de Janeiro. The impact of reversible lane management, which is currently implemented, is significant during the morning peak because of the length of lanes being managed as shown in Table 3-17 below.

**Table 3-17 List of Reversible Lane Sections in the City of Rio de Janeiro**

| Location | towards | extension (km) | time (h) | Total Lanes | Lanes reversed |
|---|---|---|---|---|---|
| Elevado do Joá | São Conrado | 3,3 | 6h30m às 8h30m | 2 | +1 |
| Av. Niemeyer | Leblon | 3,8 | 6h30m às 10h30m | 1 | +1 |
| Orlas de Leblon, Ipanema e Copacabana | Leme | 7 | 7h às 10h | 3 | +3 |
| Av. Princesa Isabel, Túnel Novo e Túnel Pasmado | Aterro | 1,9 | 7h às 10h | 4 | +2 |
| Rua Prof. Manoel de Abreu | Centro | 1,1 | 6h30m às 11h | 2 | +2 |
| Rua Visconde de Niterói | Centro | 1,1 | 6h às 9h | 2 | +1 |
| Rua Jardim Botânico | Gávea | 1,8 | 17h às 21h | 2 | +1 |
| Rua Humaitá | Jardim Botânico | 0,6 | 17h às 20h | 3 | +1 |
| Av. Rodrigues Alves | Av. Brasil | 0,7 | 16h às 20h | 3 | +1 |
| Rua Teixeira Soares - Radial Oeste | Méier | 0,6 | 16h30m às 20h30m | 4 | +1 |

Source: JICA Study Team

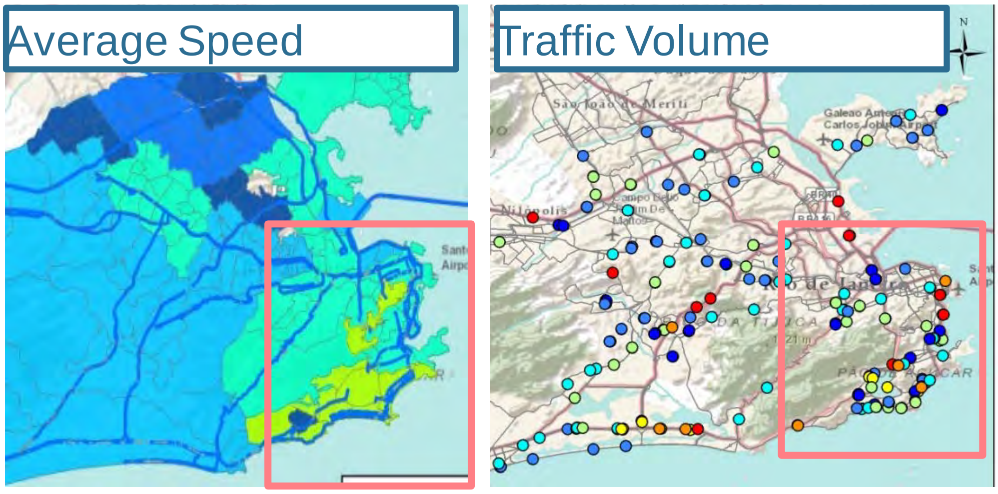



Source: JICA Study Team

**Figure 3-73 Evaluation Area for Lane Management**

2) Electronic Road Pricing (ERP)

The main areas for the ERP analysis are Centro and Copacabana wherein traffic speed is relatively slow and traffic volume is high. The area for ERP, which is shown in Figure 3-74 below, was determined based on traffic indicators such as travel speed and traffic volume. The impact of ERP is significant during the whole day.




Source: JICA Study Team

**Figure 3-74 Evaluation Area for ERP**

3) Dynamic Traffic Information Provision to Every User

The main areas for the dynamic traffic information provision analysis are the central and south regions of Rio de Janeiro. It is important to consider the route choice from Barra to Centro areas. The benefits of dynamic traffic information provision are realized by building a traffic management center that collects, processes, and provides traffic information in real time. The effect of this service is significant during the morning peak because of the demand characteristics.


Source: JICA Study Team

**Figure 3-75 Evaluation Area for Dynamic Traffic Information Provision**

4) Bus / BRT Signal Optimization

The main area for the bus signal optimization analysis is around the planned BRT terminal for the Olympic Games in Barra da Tijuca. The BRT priority signals, which have already been installed along the BRT line, are controlled to give green time to a BRT vehicle same as when green time is extended when a bus approaches an intersection. This system can be installed on local bus routes such as in the Maracana area.

Source: JICA Study Team

**Figure 3-76 Evaluation Area for Bus Signal Optimization**

5) Bus Location System

The main area for the bus location system analysis is around busy local bus stops such as the north area of Rio de Janeiro. Currently, users stand on the traffic lane (due to the large amount of people) so that they can see the approaching buses. Sometimes, this can create a bottleneck. This condition might be solved by providing bus approach information to encourage passengers, who know when their bus will arrive, to stay within the bus stop shelter.


Source: JICA Study Team

**Figure 3-77 Evaluation Area for Bus Location**

6) ETC

The main area for the ETC analysis includes expressway toll gates such as Rio-Niteroi Bridge and other concession roads. This service allows vehicles to not stop at toll gates, minimizing congestion and queues at the toll gate.


Source: JICA Study Team

**Figure 3-78 Evaluation Area for ETC**

(3) Analysis Result

1) Macroscopic Analysis

**i) Reversible Lane Management**

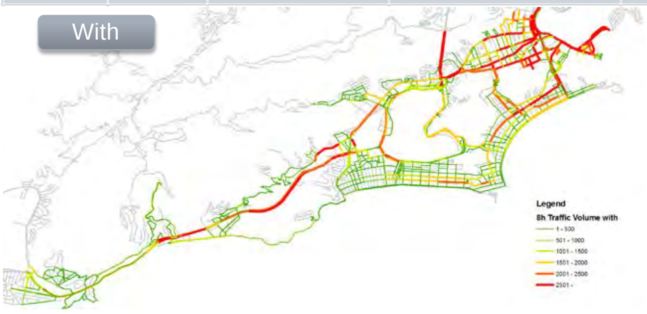
The lane control along the Barra to Copacabana route seems to be not effective because the traffic volume along the route, which is parallel to the controlled route, increases, and the traffic volume along the controlled route is less than its existing capacity.

On the other hand, the lane control along the Copacabana and Botafogo route is effective because it seems that the traffic volume is increased along the controlled route.

It is necessary to make this service dynamic and automated based on traffic monitoring information through the ITS equipment.

[Traffic Volume]

| Case | Year | Time | Network | Figures |
|---|---|---|---|---|
| LM - 1 | 2011 | 8 AM | Reversible Lane | Traffic Volume of with case and without case |



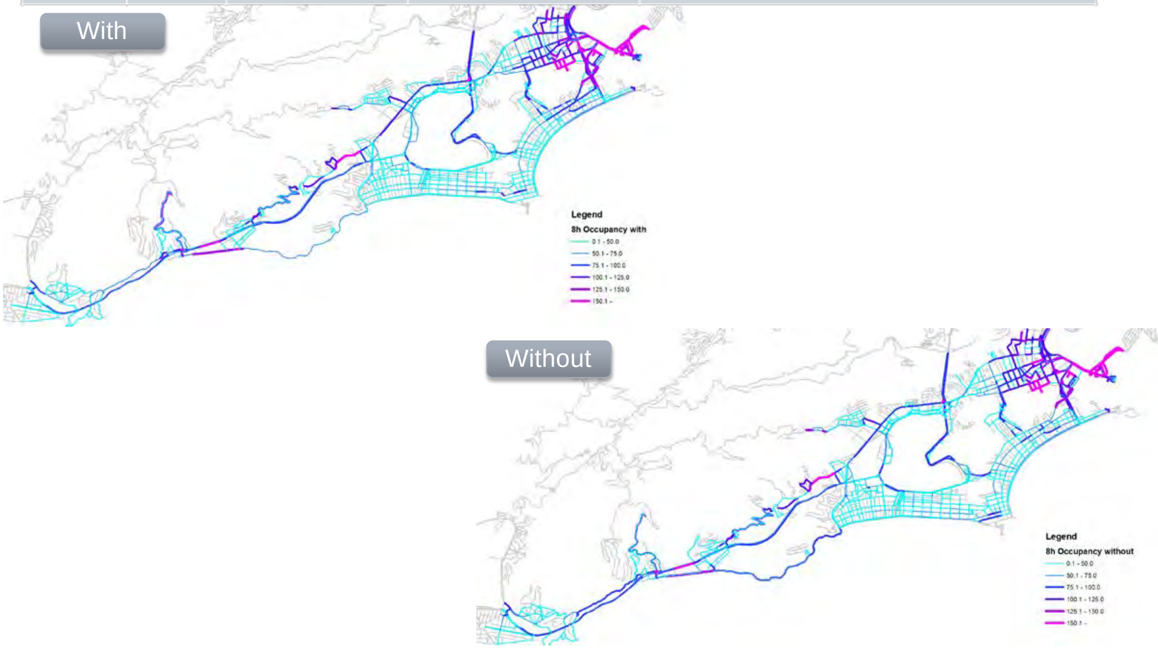


Source: JICA Study Team

**Figure 3-79 Traffic Volume With and Without Reversible Lane Management**

[Occupancy (%)]

| Case | Year | Time | Network | Figures |
|---|---|---|---|---|
| LM - 1 | 2011 | 8 AM | Reversible Lane | Occupancy of with case and without case |




Source: JICA Study Team

**Figure 3-80 Occupancy With and Without Reversible Lane Management**

[Difference between With and Without Cases]

| Case | Year | Time | Network | Figures |
|---|---|---|---|---|
| LM - 1 | 2011 | 8 AM | Reversible Lane | Difference between with case and without case |


Source: JICA Study Team

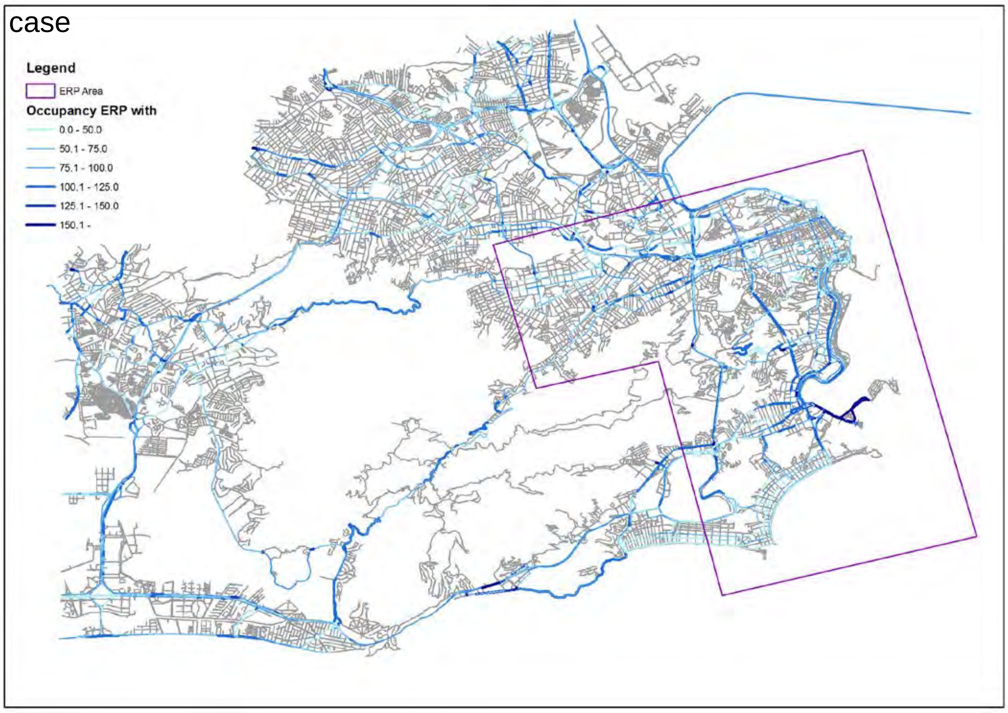
**Figure 3-81 Difference of Traffic Volume With and Without Reversible Lane Management**

**ii) ERP**

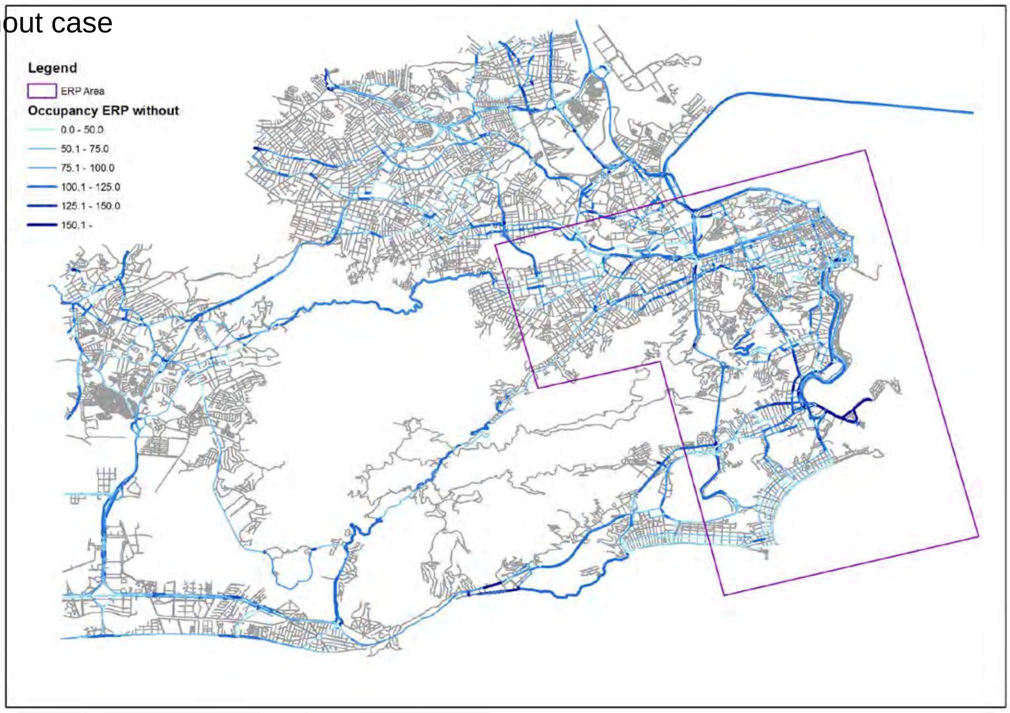
Figure 3-82 below shows the traffic condition assuming 20% traffic demand reduction in the central area. As a result, the occupancy in the central area will be decreased to less than 100%.

[Occupancy (%) per day]

with case




without case

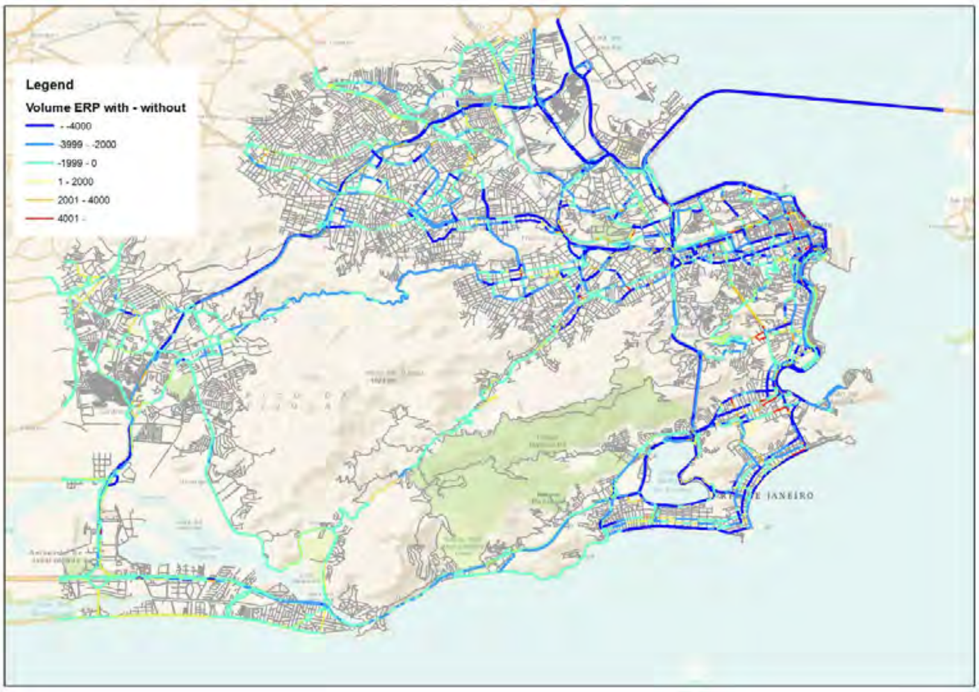



Source: JICA Study Team

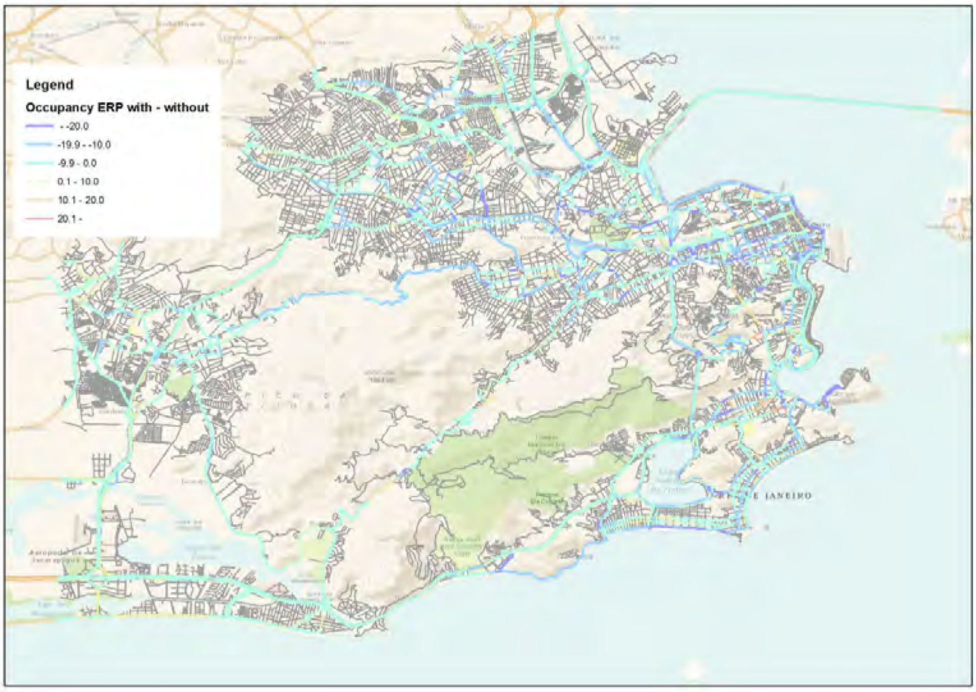
**Figure 3-82 Occupancy With and Without ERP**

[Difference between With and Without Cases]

- Traffic Volume per day




- Occupancy per day (%)




Source: JICA Study Team

**Figure 3-83 Difference of Traffic Condition With and Without ERP**

2) Mesoscopic and Microscopic Analyses

Based on the mesoscopic and microscopic analyses, the traffic indicators were calculated as shown in Table 3-18 below. In all the menus, the traffic conditions improved under the "with" case.

**Table 3-18 Comparison of Traffic Indicators between With and Without Cases**

| Menu | Indicators | Unit | 2016 | | 2021 | |
|---|---|---|---|---|---|---|
| | | | Without | With | Without | With |
| [Meso] Dynamic Information Provision | Time Delay | s/km | 49.1 | 36.9 | 49.1 | 39.2 |
| | Density | veh/km | 8.1 | 6.2 | 8.3 | 6.7 |
| | Mean Queue Length | veh | 24919.7 | 14839.0 | 25972.9 | 16897.0 |
| | Speed | km/h | 35.7 | 43.0 | 36.3 | 42.3 |
| | Travel Time | s/km | 127.1 | 100.2 | 125.5 | 103.0 |
| [Micro] Bus / BRT Signal Optimization ※Calculated for bus only | Time Delay | s/km | 57.0 | 45.1 | 50.7 | 45.2 |
| | Density | veh/km | 1.0 | 0.9 | 1.1 | 1.0 |
| | Mean Queue Length | veh | 369.5 | 329.2 | 433.8 | 363.5 |
| | Speed | km/h | 28.0 | 38.5 | 51.0 | 38.2 |
| | Travel Time | s/km | 152.2 | 108.7 | 139.0 | 109.6 |
| [Micro] Bus Location System | Time Delay | s/km | 50.6 | 36.1 | 68.4 | 38.0 |
| | Density | veh/km | 11.6 | 9.8 | 13.3 | 12.4 |
| | Mean Queue Length | veh | 2784.7 | 2238.0 | 3125.9 | 3108.8 |
| | Speed | km/h | 48.9 | 48.7 | 45.7 | 48.3 |
| | Travel Time | s/km | 116.6 | 102.3 | 136.7 | 104.3 |
| [Micro] ETC | Time Delay | s/km | 21.6 | 7.4 | 21.0 | 6.8 |
| | Density | veh/km | 8.7 | 6.7 | 8.5 | 6.6 |
| | Mean Queue Length | veh | 4.0 | 0.2 | 3.1 | 0.2 |
| | Speed | km/h | 66.4 | 84.5 | 66.7 | 85.8 |
| | Travel Time | s/km | 58.5 | 44.7 | 57.8 | 43.9 |

Source: JICA Study Team (i–iv)

# 3.4 OLYMPIC GAMES TRANSPORT STUDY

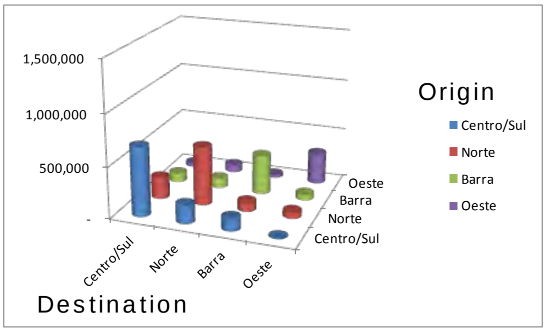
## 3.4.1 Background Demand Characteristics in 2016

(1) Number of Trips in Rio City

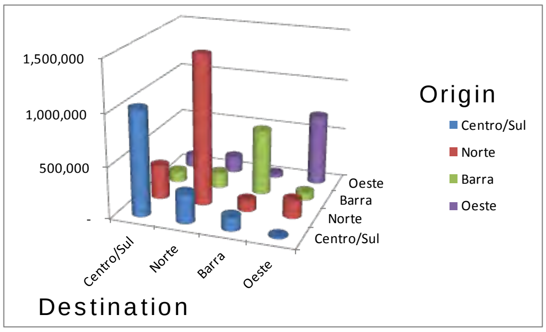
Figure 3-84 below shows the 2016 demand characteristics in the city of Rio de Janeiro. The demand between Centro/Sul and Norte/Barra and bus trips in the Norte area are remarkable. It should be noted that the number of trips by bus is much larger than that by car.


Rio: Barra, Centro / Sul, Norte, Oeste

**Car**




**Bus**



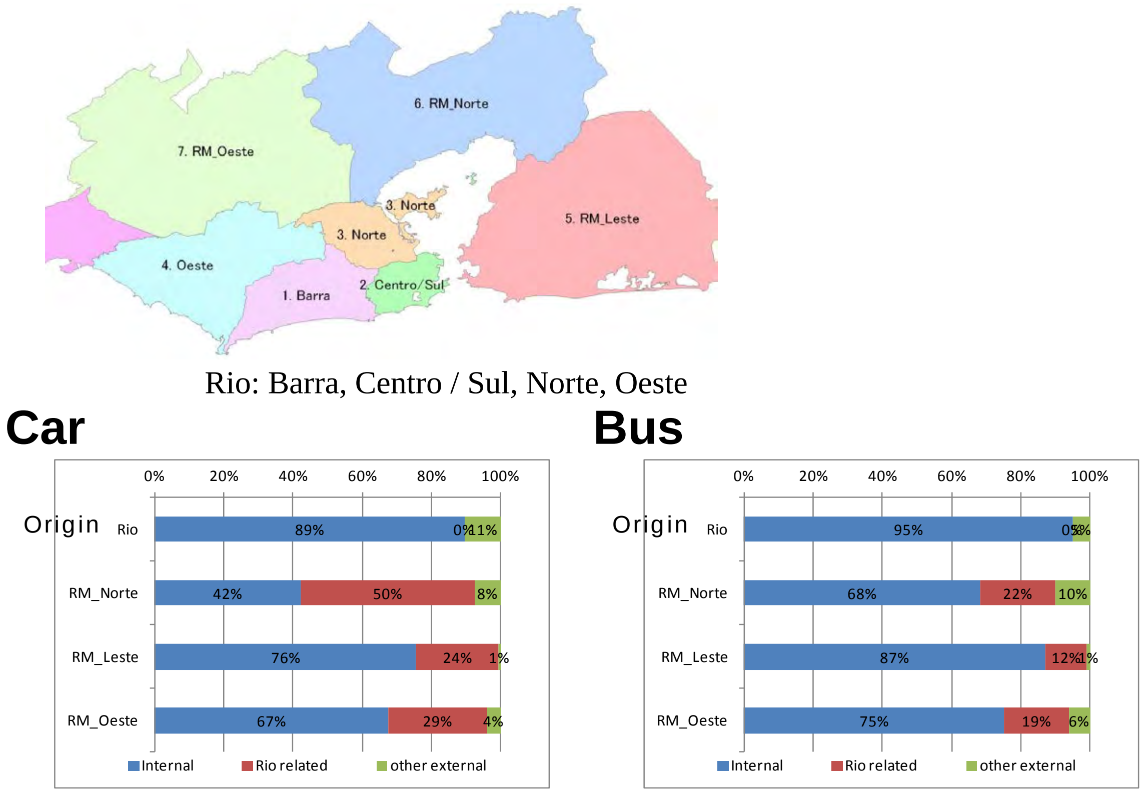

Source: 2016 OD data estimated from 2003 PDTU OD and 2011 OD

**Figure 3-84 Demand Characteristics in the City of Rio de Janeiro in 2016**

(2) Number of Trips in RMRJ

Figure 3-85 below shows the 2016 demand characteristics in the RMRJ. The demand from the surrounding cities to Rio City by car is about 24% to 50% of the whole trips from each subregion.

The proportion of external trips by car is higher than that by bus, which means that long distance trips are conducted by car rather than by bus.




Source: 2016 OD data estimated from 2003 PDTU OD and 2011 OD

**Figure 3-85 Demand Characteristics in the Metropolitan Region of Rio de Janeiro in 2016**

(3) Demand Characteristics in RMRJ

Figure 3-86 summarizes the demand characteristics in the RMRJ. This background demand will be considered in the final Olympic Games transport strategy formulation.


Source: JICA Study Team

**Figure 3-86 Image of Demand Characteristics in Rio**

(4) Key Issues on Background Demand

As shown in Figure 3-87, the key issues derived from the demand characteristics in Rio are as follows:

- Internal demand in the city of Rio de Janeiro by car and bus;
- Car demand between the city of Rio de Janeiro and others; and
- Congestion points caused by background demand.

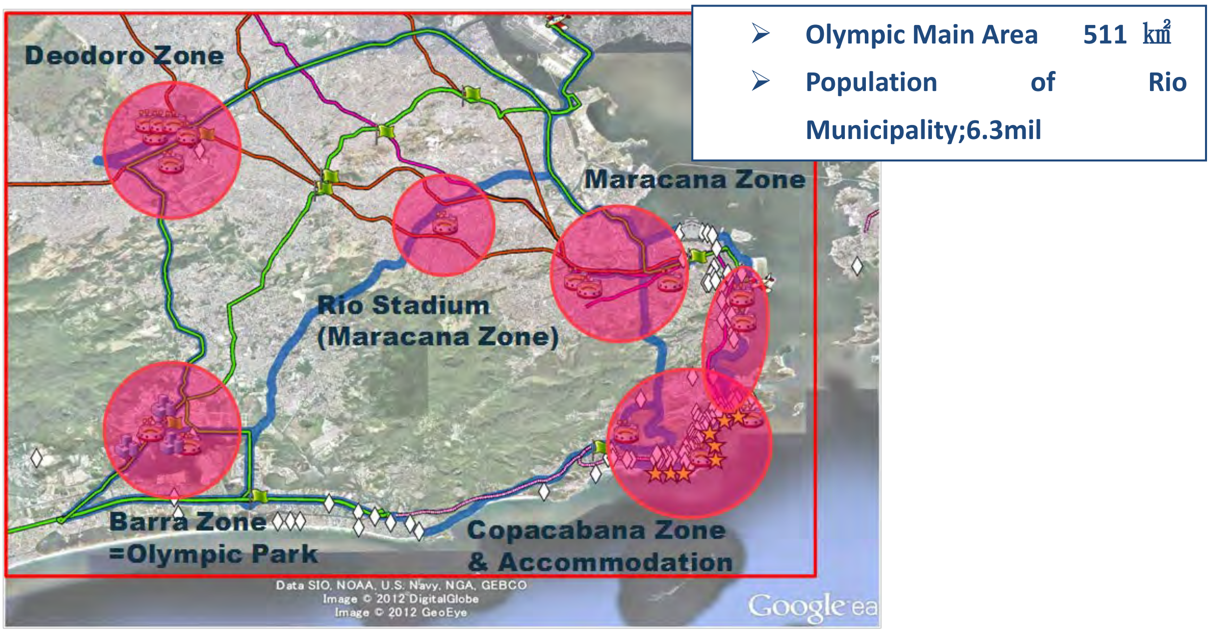

Source: JICA Study Team

**Figure 3-87 Key Issues on Background Demand in Rio**

### 3.4.2 Olympic Games Transport Characteristics

(1) Olympic Games Main Area

Figure 3-88 shows the Olympic Games venues located in the city of Rio de Janeiro. The venues are mainly divided into five zones. The Olympic Games family demand and spectators demand in each venue will be further discussed.




Source: JICA Study Team

**Figure 3-88 Olympic Areas**

(2) Olympic Games Family Demand

The Olympic Games family consists of athletes and team officials, national Olympic committees (NOCs), technical officials, and media. The number of visitors is estimated to be 78,000 in total during the games. In order to control this demand, 850 buses, 2,900 sedans, and coach service are planned.

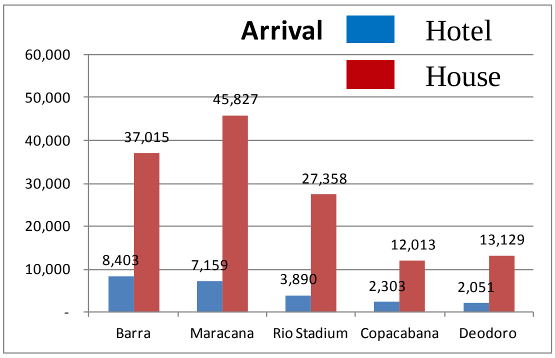
**Table 3-19 Olympic Games Family Demand**

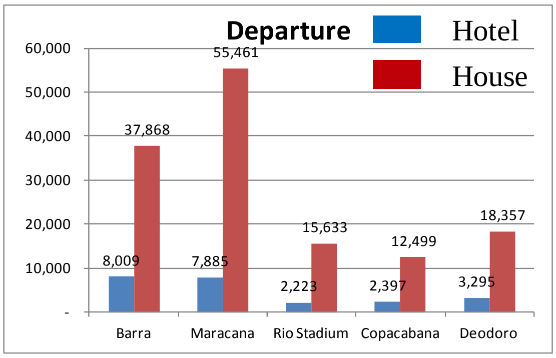
| Client | Number | Mode | Accomocation |
|---|---|---|---|
| Athletes and Team Officials | 15,500 | Bus: 300 | Olympic Village |
| NOC (National Olympic Committee) | - | Sedans (and Minivans): 900 | - |
| Technical Officials | 3,500 | Bus (and Minivans): 150 | Barra |
| Media | 22,000 | Bus: 400 | Barra Media Village and Other Hotels |
| T1 - T3 (IOC member etc. ) | 5,000 | Sedans (and Minivans): 2,000 | Games Family Hotel (Copacabana) |
| Marketing Partners | 32,000 | Coach services | Various |

Source: JICA Study Team

(3) Spectators Demand

Figure 3-89 below shows the peak spectators demand by zones. The Barra and Maracana zones will have high demands with about 60,000 spectators during the peak hour.




| Arrival Peak Time | Day | Time |
|---|---|---|
| Barra | 3 | 8 |
| Maracana | 11 | 16 |
| Rio Stadium | 10 | 17 |
| Copacabana | 9 | 8 |
| Deodoro | 11 | 16 |

| Departure Peak Time | Day | Time |
|---|---|---|
| Barra | 6 | 22 |
| Maracana | 10 | 21 |
| Rio Stadium | 10 | 21 |
| Copacabana | 9 | 13 |
| Deodoro | 13 | 21 |

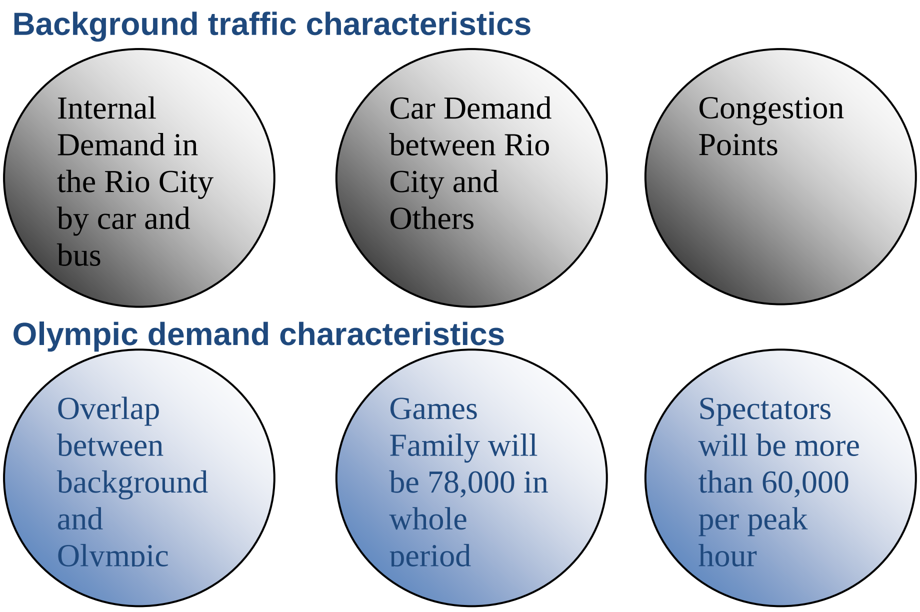
Source: JICA Study Team

**Figure 3-89 Peak Spectators Demand**

(4) Key Issues on Olympic Games Transport

Similar to the key issues on background demand, the key issues derived from the Olympic Games demand characteristics in Rio, as shown in Figure 3-90, are as follows:

- Overlap between background and Olympic demands;
- Olympic Games family demand will be 78,000 during the whole period; and
- Spectators will be more than 60,000 per hour during the peak time.




Source: JICA Study Team

**Figure 3-90 Key Issues on Olympic Demand**

(5) Need for Olympic Games Transport Management

Based on the analysis of background and Olympic demand characteristics, the objectives of the Olympic transportation plan are as follows:

**Traffic Management: Olympic Games Family**

To manage the condition of background traffic demand in Centro/Sul/Norte/Barra areas during the period of the Olympic Games

To provide reliable Olympic Games family transport mixed with background traffic

**Transport Management: Spectators**

To manage the condition of background transport demand in Centro/Sul/Norte/Barra areas during the period of the Olympic Games

To provide reliable public transport service at competition venues during the peak time of spectators demand

### 3.4.3 Transport for Olympic Games Family Demand

(1) Vehicle Demand for Olympic Games Family

Based on the Rio 2016 Transport Strategy Study, the basic OD data for Olympic Games family demand are depots in Barra and Centro areas for car parking around the zones.

The main movement of Olympic Games family traffic flow is shown in Figure 3-91 below.

**Table 3-20 Main OD of Olympic Games Family Demand**

Depot ⟷ Parking

Depot

| Location | Target | Mode | Capacity |
|---|---|---|---|
| Barra Depot 1.1 | Athletes and Team officials | Bus | 400 |
| Barra Depot 1.2 | Technical officials | Bus | 100 |
| Barra Depot 2 | Media transport system | Bus | 500 |
| Barra Depot 3 | T1 - T3 transport system | Vehicle | 2,000 |
| Leopoldina Depot (Centro) | Technical officials | Bus | 50 |
| | T1 - T3 tansport system | Vehicle | 700 |

Parking

| Location | Spaces |
|---|---|
| Riocentro | 1,150 |
| Rio Olympic Park | 2,200 |
| Deodoro Zone | 2,145 |
| Copacabana Zone | 3,765 |
| Maracana Zone | 2,400 |
| Olympic Village | 1,500 |
| IBC / MPC | 1,300 |
| International Airport | 2,000 |
| IOC Hotel | 300 |


**Figure 3-91 Main Flow of Olympic Games Family Demand**

(2) Management of Olympic Games Family Demand

Considering the main flow of the Olympic Games family demand, the management strategies are described as follows:

**Proposed Management (ITS services)**

1. Travel time information along Olympic Lanes for background traffic and Olympic Games family traffic
2. Traffic control along the BRT corridor (TransOlympica, TransOeste), which is also set as an Olympic Lane.
   e.g., Priority signal control for BRT and Olympic Games family demand
3. Information provision of parking occupation