TRAFFIC AND PUBLIC TRANSPORT PLANNING FOR OLYMPIC GAMES: CHALLENGES FOR THE CITY OF RIO DE JANEIRO

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ABSTRACT

The preparation of the city for mega events as Olympic is a great challenge to transportation planners. At the same time, they have to deal with the duties assumed during the bid for International Olympic Committee and the daily responsibility of offering good transport and road services for the city inhabitants. This paper reports how the transport and traffic departments are planning the traffic and transport networks for the event in the City of Rio de Janeiro in 2016. The topographic conditions limits the number of arterial connections and the social economic aspects related to modal split and urban segregation make the City of Rio de Janeiro an interesting case for future events in developing countries.

Keywords: Transport Planning, Mega-events.

THE TRANSPORT CONCEPT: HIGH PERFORMANCE RING

The Transport Strategic Plan for the Rio 2016 Olympic and Paralympic Games delivered in 2009 was a document that described the transport concept of the City of Rio de Janeiro to enhance the quality and to upgrade the public transport to host Olympic and Paralympic Games (BRAZILIAN OLYMPIC COMMITTEE, 2009). It was part of the bid documents for 2016 Summer Olympic and Paralympics that the candidate cities that aimed to host the Games of the XXXI Olympiad had to submit. It was based in providing the city with a High Performance Transport Ring that connects all the four Olympic zones (Deodoro, Barra, Copacabana and Maracanã) with public and accessible transport. It considered an upgraded program of suburban railways that provides access to the Deodoro and Maracanã zones, extension of existing metro Line 1 that provides access to the Maracanã Stadium and Copacabana and, finally, the deployment of three high capacity Bus Rapid Transit (BRT)

systems (Corridor T5[1], Barra-South Zone and Link C), that closes the ring and provides access to Barra, Deodoro and Copacabana. The BRT was designed to serve as an extension of the metro and suburban rail systems through interchanges, and also as the route for the Olympic Family fleet. Other relevant projects include the construction, extension and widening of the road network (167 km), upgrades and major new investments in traffic management systems, and significant enhancements of the regular bus services. The Transport Concept was developed in close partnership between all three levels of Government[2] to ensure that it will support and accelerate city, state and national long-term development strategies.

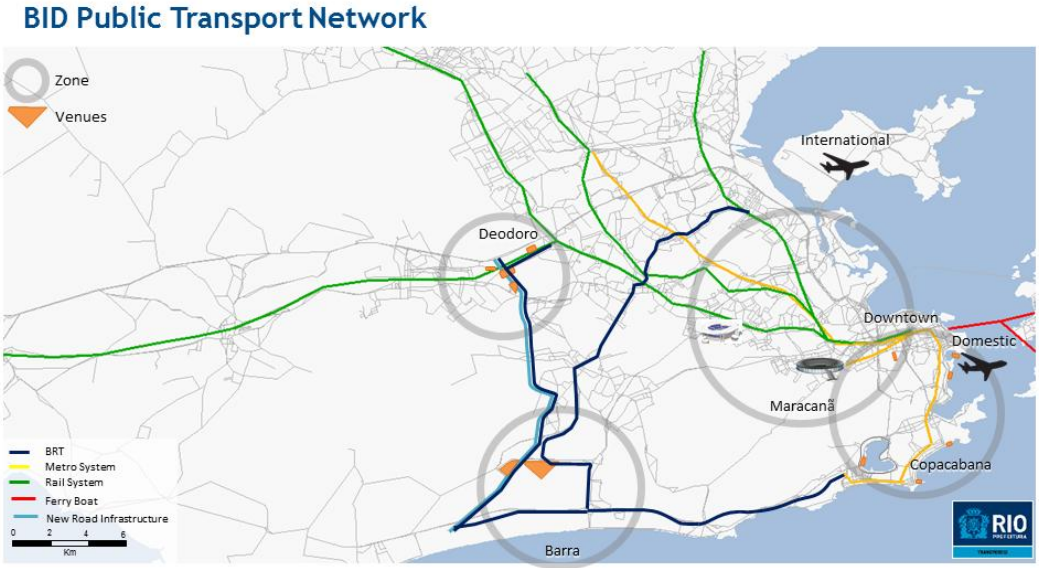

Figure 1 – Schematic Map of BID Public Transport Network

Source: Adaptation from Brazilian Olympic Committee, 2009

This 2009 document was based in city's public transport infrastructure that already provide the high share of daily trips served by the system: 9.7 million daily trips that account for more than the 75% of the total trips. This share is based on the rail network of five suburban rail lines (225 km, 89 stations) that connects the north and northeast areas of the city to the CBD; the two Metro lines (37 km, 33 stations), which provide a high frequency connection between the CBD and the South Zone; the dense, high frequency bus system of 1,450 routes that currently covers the entire metropolitan area of Rio de Janeiro and the ferry services (three lines) linking downtown to the suburban Governador Island and the city of Niteroi via Guanabara Bay.

[1] Corridor T5 is the first transverse public transport connection in the city of Rio de Janeiro.
[2] Each level of Government in the City of Rio de Janeiro has a different role in Transport Network. Federal level: airports, State level: metro and train, City level: BRT, bus, LR.

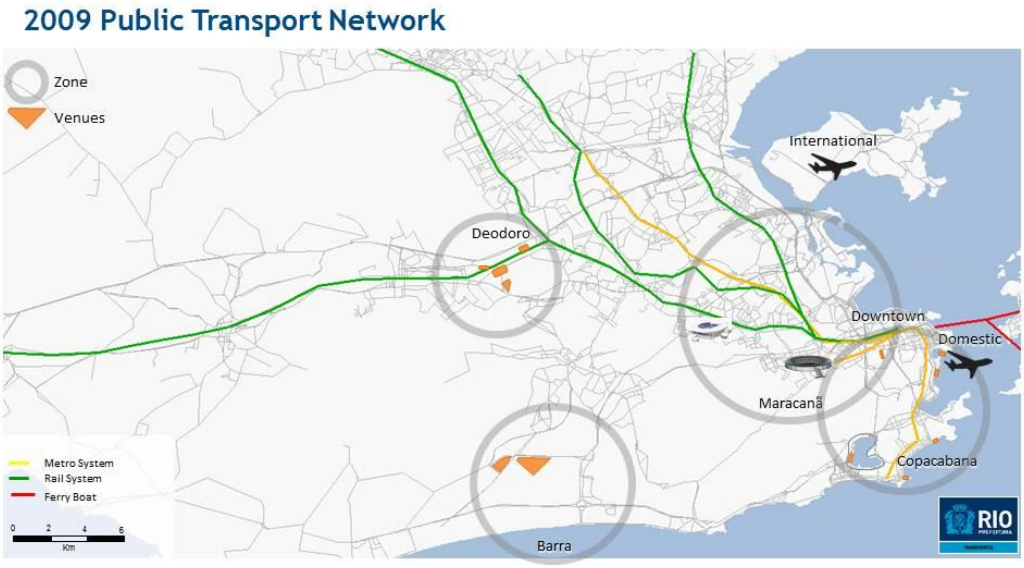

Figure 2 – Schematic Map of Public Transport Network in 2007

In 2012, when the Transport Strategic Plan was updated, it also considered the changes in the location of some Olympic and Paralympic Venues and the upgrade of the High Performance Transport Ring (SMTR et al, 2012). First of all, some venues were located in Port Area in Downtown where a process of urban revitalization is taking place. The updated High Performance Ring considers the maintenance of the program of suburban railway that provides access to the Deodoro and Maracanã cluster, but also includes some changes like: the new Metro Line 4 as an extension of existing metro Line 1 reinforcing the connections between the CBD , Maracanã and Copacabana Zones with Barra zone; the deployment of four high capacity Bus Rapid Transit (BRT) systems: Transcarioca, (ex-T5) with connection to the International Airport, Transolímpica, (ex-link C), Transoeste, ex-Barra-South Zone with connection to Metro line 4 to far west Santa Cruz and Transbrasil, upgrade of main express corridor of the city, that closes the ring and provides access to Barra and Deodoro zones. It increases the network of Olympic Lanes as it is planned to use the BRT lane. The BRTs was considered to serve as extensions of the metro and suburban rail systems through interchanges. There is also the development of Port LRT network to transform the landscape and improve the infrastructure of downtown and port area.

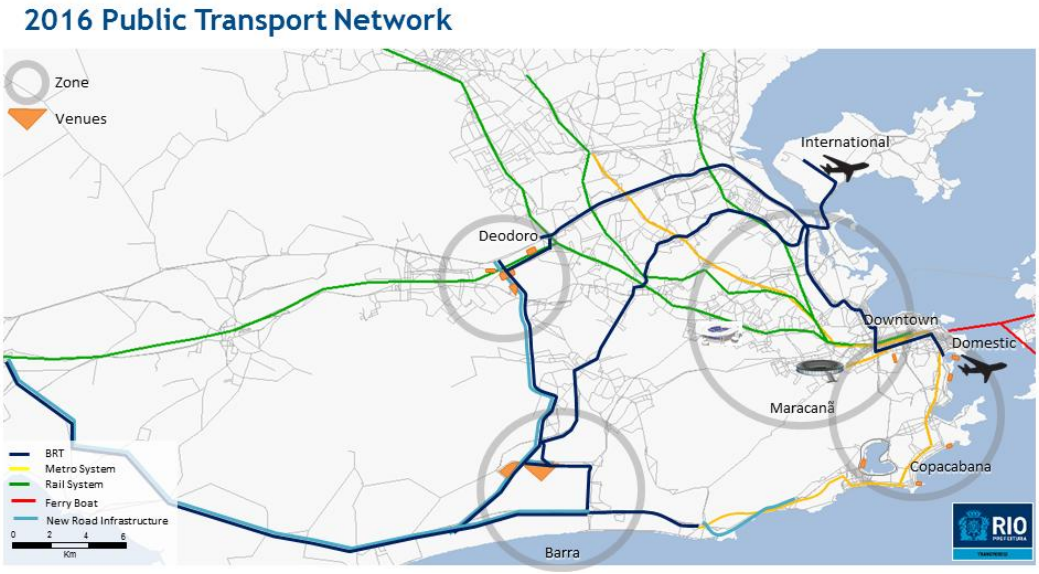

Figure 3 – Schematic Map of Public Transport Network for 2016

The goal of these investments was to assure the legacy of the Games regarding the public transport infrastructure. That's why they included the Port area in downtown as venue to the Referee and Media Village, the connection to the International and Domestic Airport and the inclusion of BRTs that provide alternative rings where the inhabitants also needed like BRT Transoeste and BRT Transbrasil. So, the High Performance Ring Concept that connects the Olympic Zones, and also Paralympic Zones, was kept but it was upgraded to include alternative routes to the spectators and mainly daily commuters. The City of Rio de Janeiro took the opportunity of this mega-event to create a long-term public transport infrastructure for its citizens.

OLYMPIC LANE NETWORK

The experience of the implementation of Olympic Lanes Network (OLN) since the Athens Games has proved to be a success. Learning from the successes of previous Olympic and Paralympic Games and building on Rio's experience during the 2007 Pan American Games, an Olympic Lane network of more than 150 km per direction has been designed.

Defining Routes

The Olympic Lane Network is comprised of a network of roads, connecting all competition and major non-competition venues. These roadways fall into two categories:

- Main motorways and major arterial roads that comprise the backbone of the OLN and provide connections among all four venue clusters, which include BRT lanes.

- Roads within the local network of the venue zones that connect the competition and non–competition venues with the backbone network.

The Olympic Lane network, shown on Figure 4, has been designed in order to allow for congestion free travel of the Games Family, accommodate the estimated Games traffic flows and maintain the required levels of security. Its main characteristics are:

- The network's backbone is based on a hub and spoke design connecting Barra, where the majority of competition venues and major non-competition venues are located, with the other venue zones

- The network's backbone mainly consists of roads with at least three lanes per direction, of which one will be dedicated to the exclusive use of the Games Family vehicles. It provides direct connection with the international and domestic airports and easy access to the majority of training venues. It enables easy navigation and caters for the implementation of signalling priorities (green waves). It supports the designation of contingency routes for emergency management.

The contingency routes use the BRT exclusive lanes (Figure 5).

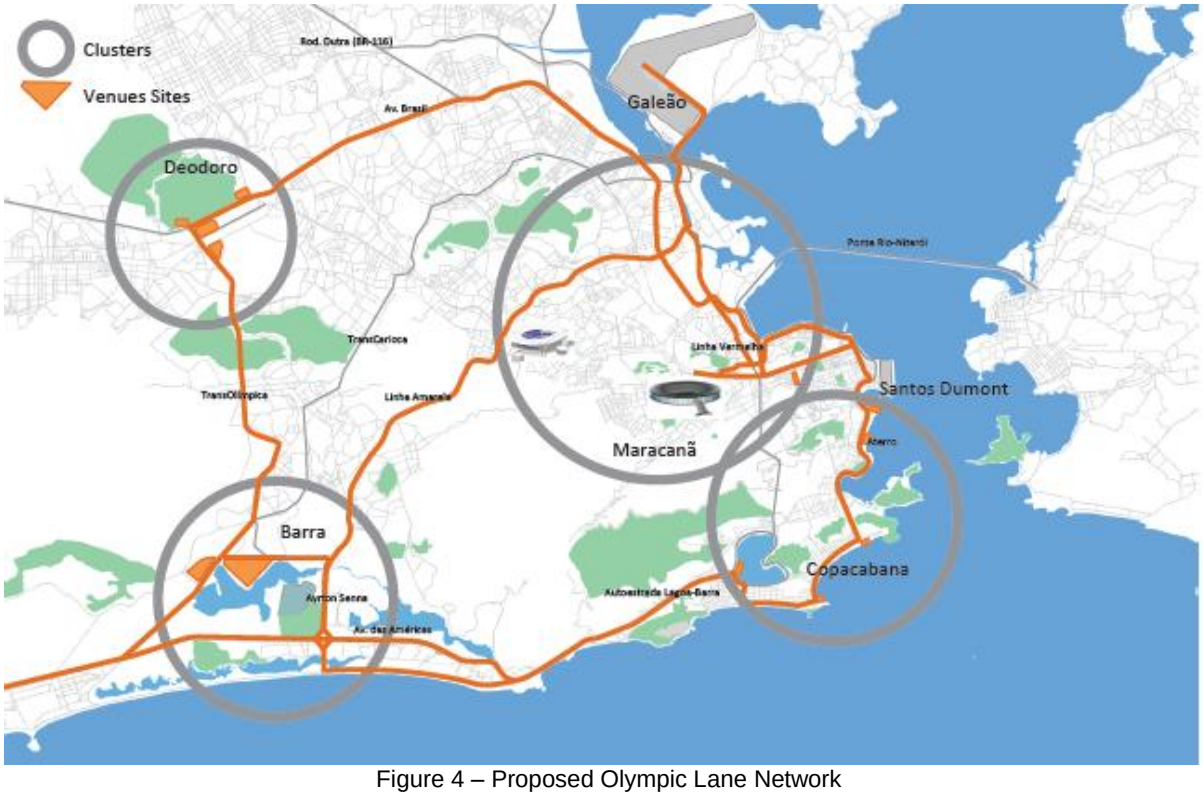

Figure 4 – Proposed Olympic Lane Network

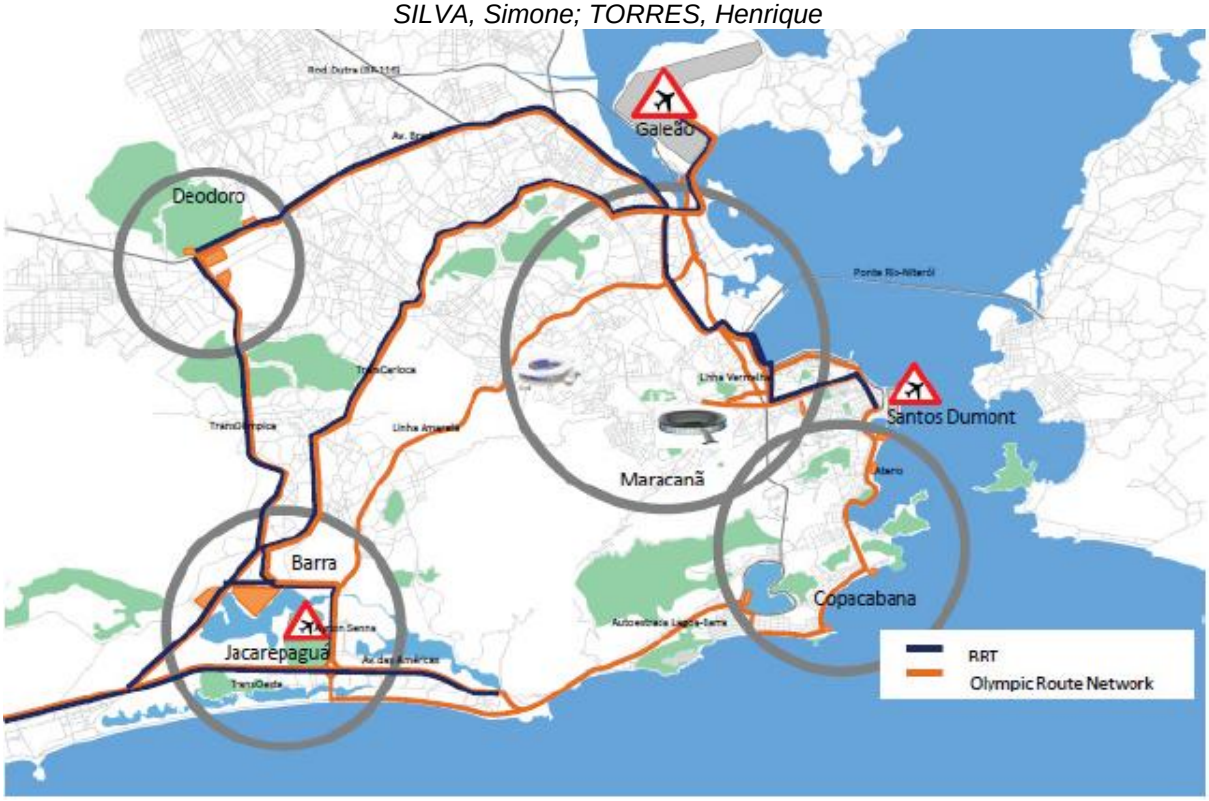

Figure 5 – Alternative Olympic Lane Network

ITS support measures

Management of the Olympic Lane network and, in general, of city traffic in Games-sensitive areas will greatly benefit from Rio's committed Intelligent Traffic System (ITS) investments. Since 1996, the city has implemented an integrated traffic management center (CTA) covering critical areas of the city, such as Rio's downtown (City Center), the South Zone, portions of Barra and major motorways of the city. The current system employs 530 monitoring cameras, 1300 traffic loops for data collection and speed detection, 46 Variable Message Signs, and 500 license plate identification devices (OCR). Using this real time information, the timing of traffic signals is managed at 1,100 intersections.

Phase 1 of the two-phased upgrade program that exceeds USD110 million was completed in 2009, modernized all existing software and hardware infrastructure, and upgraded the traffic control room. Phase 2 of the upgrade program, to be completed prior to the 2014 FIFA World Cup, will further enhance the city's traffic command and control systems. A second traffic control center (CCO) will be developed to integrate the existing one, the control centers of key public transport modes (Metro, Suburban Railway, Ferries), the centers of the motorway concessions (Red Line and Yellow Line) and those of the tunnels. A direct link to the police and emergency services command centers will be also provided, with respective representatives located at CCO. New monitoring devices will be added including 100 cameras, 10 Variable Message Signs, 1,000 traffic loops and 302 license plate identification devices to add 1,500 intersections to those that are controlled remotely.

Some outcome for games family and city commuters

The Olympic Lane network will enable 36% of athletes to reach the Olympic Village within 10 minutes and 62% to do so within 25 minutes. On the other hand, with 23 of the 40 training venues located within the Barra Zone, 68% of all athletes will reach their training sites within 15 minutes and 91% will do so within 35 minutes. Training venues outside the Barra Zone are accessed via the Olympic Lane network, with some travel outside the network facilitated by special traffic arrangements.

Extensive transport modelling with AIMSUN software for micro-simulation has been used to analyze the effectiveness of the proposed Olympic Lane network, and of the measures discussed above, under conditions of the year 2016 (MODELLE, 2012). The reliability of schedules for the Games Family is of utmost importance. Figure 6 shows that the travel times on the OLN between the Olympic Park and the Pier Mauá will be 48 minutes.

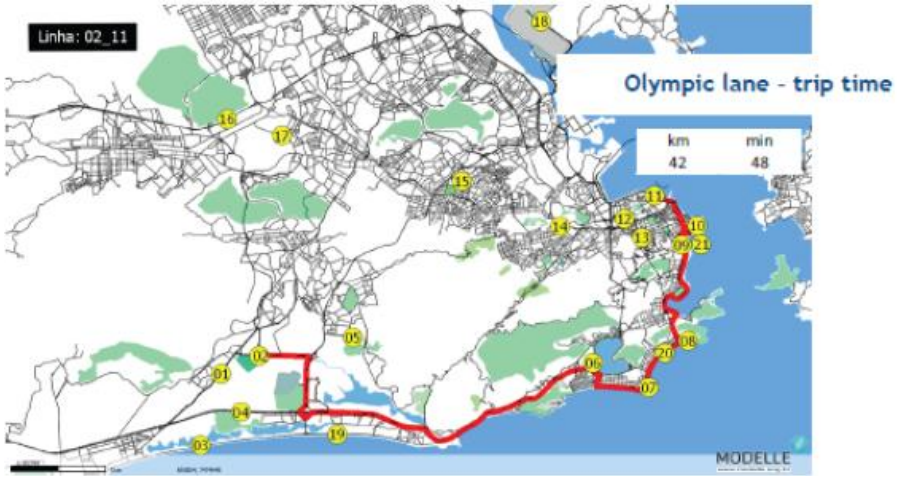

Figure 6 – Travel time on OLN between Olympic Park and Pier Mauá

Figure 7 shows the city traffic conditions during the busiest day and period of the Games (morning of Day 10), considering a moderate demand reduction of about 20%; this reduction is attributed to some of the traffic measures and travel demand management schemes discussed above. The figure compares the traffic loads to road capacity during this peak period. From the figure it is clear that, even under moderate demand reduction, there is limited congestion. Using most of the traffic and proposed demand management measures, a more significant than 20% reduction is expected. This provides a good safety margin and indicates that an even more favourable traffic situation may be achieved.

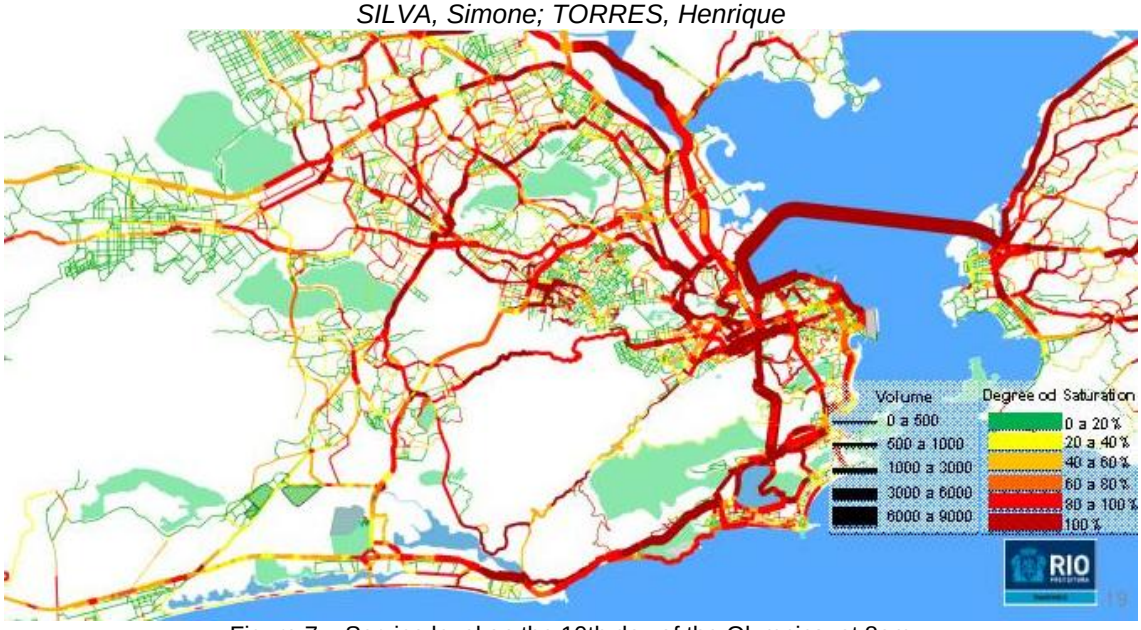

Figure 7 – Service level on the 10th day of the Olympics, at 8am

Simulations were done to determine the impact of the Olympic Lanes Network over the background traffic. As an example, the following map shows the increasing of 29% in travel time between Barra and the Red Line (Figure 8).

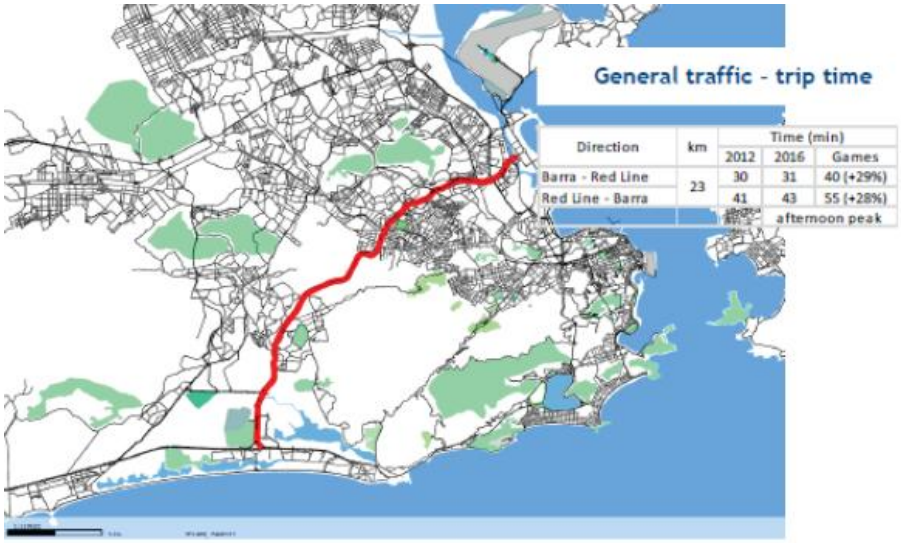

Figure 8 – Comparisons in trip time - Barra-Red Line route

COMMUTERS + EXPECTATORS IN PUBLIC TRANSPORT: THE CHALLENGE DURING GAMES TIME

The preparation of Transport Model

The analysis of the impact of spectators' trips during Games Time in the public transport network was supported by a robust transport model based on a four step modelling system (CONSÓRCIO OFICINA/LOGIT, 2012). The model is a result of years of evolution where the outline was the Transport Master Plan of Rio the Janeiro Metropolitan Area finished in 2004.

The model was successively improved to be applied in the Transport Master Plan of the City of Rio the Janeiro in 2006, in the Pan-American Games of 2007, in the BID for Rio 2016 in 2009 and in many transport studies for local and state government authorities. The model was originally implemented using TransCad and then converted to Emme software (Figure 9 and 10). To the present application many additional field surveys were made in order to update the trip matrices and the network model where all the relevant transport infrastructure are represented.

Figure 9 – Typical Day Demand for 2016

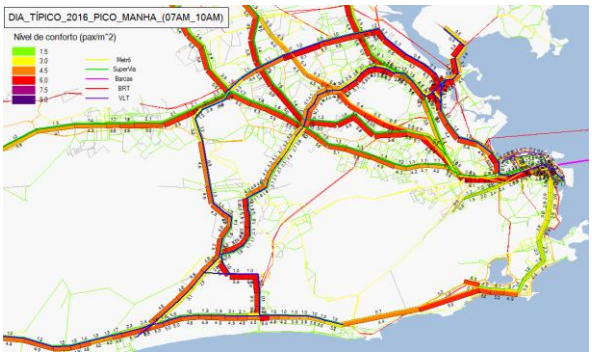

Figure 10 - Level of Service in Typical Day 2016

The first assumption considered in the model was the reduction in city pattern (?) demand due to school holidays during the Olympics. The strategy is the transfer of the school and university winter holidays from July to August. The consequence to the model is that the background demand was reduced in 20%. The background demand was minimized in all the network (Figures 11 and 12).

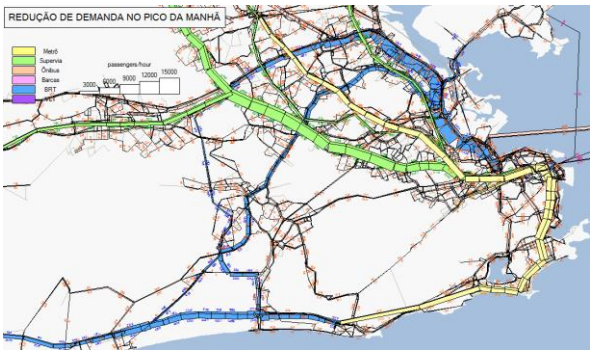

Figure 11 – Reduction of Background Demand 2016 due to TDM measures

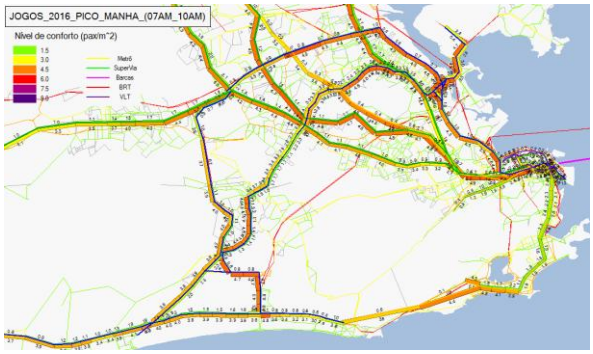

Figure 12 - Level of Service of TDM Measures 2016

Three more assumptions were considered to develop the matrix of the spectators for the Olympics and Paralympics Games: schedule linked to the capacity and location of the venues, hypotheses of public arrival and departure and popularity of sports modalities. Significant additional demand is also generated by the workforce of staff, contractors and volunteers. However, it is recognized that workforce will travel from all parts of the city to

reach their Games workplace, often at hours before and after the mass spectator mobility. At this Strategic Level, the spectators were the main client[3] considered.

1) Schedule linked to capacity and place of the venues:

Given the policy of accessing all venues exclusively by public transport, as well as the full stadiums program of Rio 2016, the Games will impose a surge in the demand of the city's public transport system. This surge has been analyzed extensively in order to guide the planning process for spectators and workforce transport. Based on the schedule and the capacity of the venues, the total number of tickets available for the Rio 2016 Games is approximately 7.7 million, over 6.1 million of which will be available for the venues in Rio, while approximately 1.6 million will be available for the events in the football cities. The total number of tickets available in the busiest day of the Rio events (Day 10) amount to approximately 517,000, as indicated in Figure 13, which shows the total number of tickets available in Rio per day of the Olympic Games.

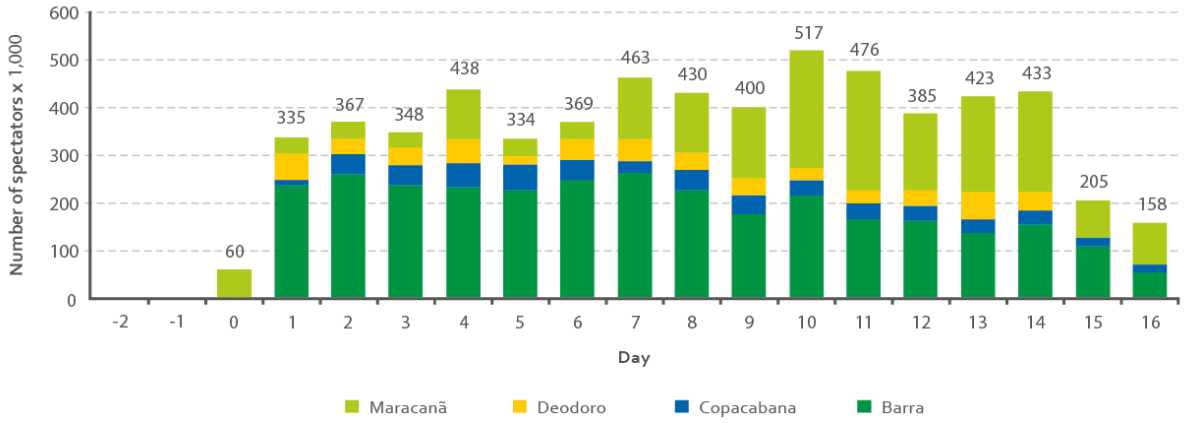

Figure 13 – Daily Demand of Olympic spectators

Figure 14 shows the expected maximum number of tickets available per competition day and venue zone throughout the Paralympic Games. At the busiest day of the Games (Day 7) up to 100.000 spectators are estimated to attend Paralympic events.

[3] There are other Olympic Clients such as workforce, volunteers, Athletes, International Federations, etc.

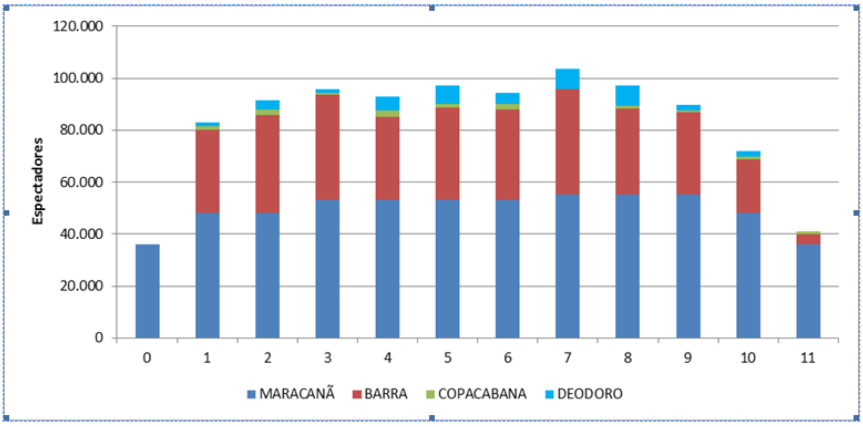

Figure 14 – Daily Demand of Paralympic Expectators

2) Hypotheses of public arrival and departure:

The hypotheses of public arrival and departure were adopted in different types of session (single, extended and multiple) to achieve the hot hours of spectators movements round venues and zones. On Figure 15, it is possible to identify a example of a single session. The same patterns were applied in the Olympic and Paralympic mode.

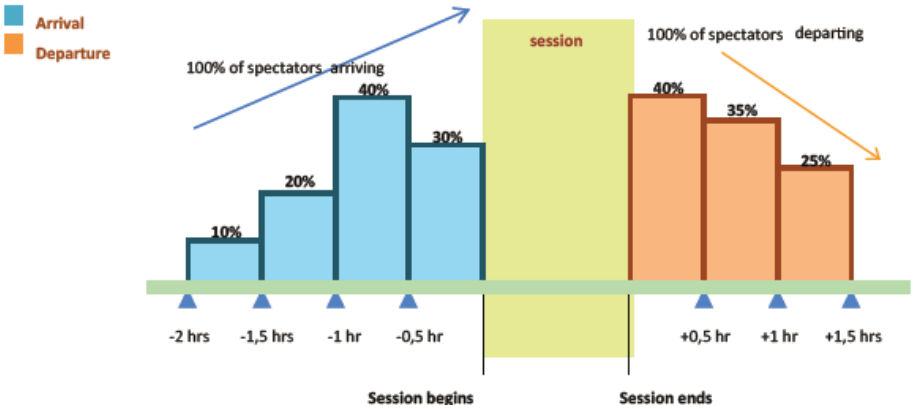

Figure 15 – Hypothesis Arrival and Departure of a single sport session

3) Popularity of sports modalities

Another factor that influences public demand is the popularity of certain sports modalities, which also depends on the type of session, whether a preliminary, semi-final or final. The factor was established upon an evaluation made in prior events, similar to those of the Games (Figure 16). For the Paralympic event, a modest pattern was adopted.

Esport Category	Esport/Event	Session´s Popularity Factor			
		F	SF	QF	P
1	Artistic Gymnastics, Volleyball, Swimming, Beach Volleyball	100%	100%	90%	90%
2	Athletics, Equestrian, Football, Judo, Tennis	93%	93%	80%	80%
3	Divng, Equestrian, Marathon, Rhythmic Gymnastics, Synchronised Swimming, Golf, Rugby	93%	93%	70%	70%
4	Canoe Sprint, Canoe Slalom, BMX Cycling, MTB Cycling, Sailing, Taekwondo, Water Polo, Canoe-Kayaking	90%	90%	65%	65%
5	Archery, Badminton, Boxing, Hockey, Handball, Marathon Swim, Marathon W, Modern Pentatlhon, Race Walking, Road Cycling, Shooting - Rifle and Pistol, Trap Shooting, Table Tennis, Diving, Triathlon, Weight Lifting, Wrestling, Greco-Roman Wrestling	85%	85%	60%	60%
-	Opening Cerimonies	95%	-	-	-
-	Closing Cerimony	90%	-	-	-

F=final; SF=semifinal; QF=qualifying; P=preliminary

Figure 16 - Example of Olympic patterns Popularity Assumption

Based on these assumptions, it became possible to identify the peak hour for each zone, considering that the zone consists of a group of different venues. Matrices of spectators demand, mainly in the critical period, were elaborated.

Zone	Arrival Peak				Departure Peak			
	Day	From	To	Maximum Arrival of Public	Day	From	To	Maximum Departure of Public
Barra	3	18:00	19:00	45,418	6	22:00	23:00	45,877
Copacabana	9	8:00	9:00	14,316	9	13:00	14:00	14,896
Deodoro	4,7,13	15:00	16:00	15,180	13	21:00	22:00	21,652
	11,12	16:00	17:00					
Maracanã	10,11	16:00	17:00	66,378	10	21:00	22:00	81,202

Figure 17 – Arrival and Departure Peak per Zone

The expected demand per venue and per time of day during the entire period of the Games has been determined in order to assess the spectator transport task per venue.

Spectators Demand Distribution

For each period of the day it was generated the distribution of the origin of the spectators to the Games and conversely from the Games to the destinations assuming the following:

- Location of the hotel rooms expected to be available in 2016 (including ships anchored in the Harbor during the Games), subtracting the rooms reserved for the Games staff.

- For the Games, each room accommodates two spectators that will necessarily attend to a unique session per day (around 65 thousand spectators). The Figure 18 shows the distribution of the lodging capacity during the Games

Figure 18 – Spatial Distribution of Hotel beds in 2016

- Resulting from the premises above, approximately 15% of the total spectators of the Games will be hosted in hotels.

- The local spectators are distributed in the region proportionally to the inhabitants of high income (the criterion is the number of residences with family income higher than 10 times the Brazilian minimum wage, based on the OD Survey for the Metropolitan Transport Master Plan of 2005). The Figure 6.10 shows the distribution of population with family income higher than 10 minimum wages (Figure 19).

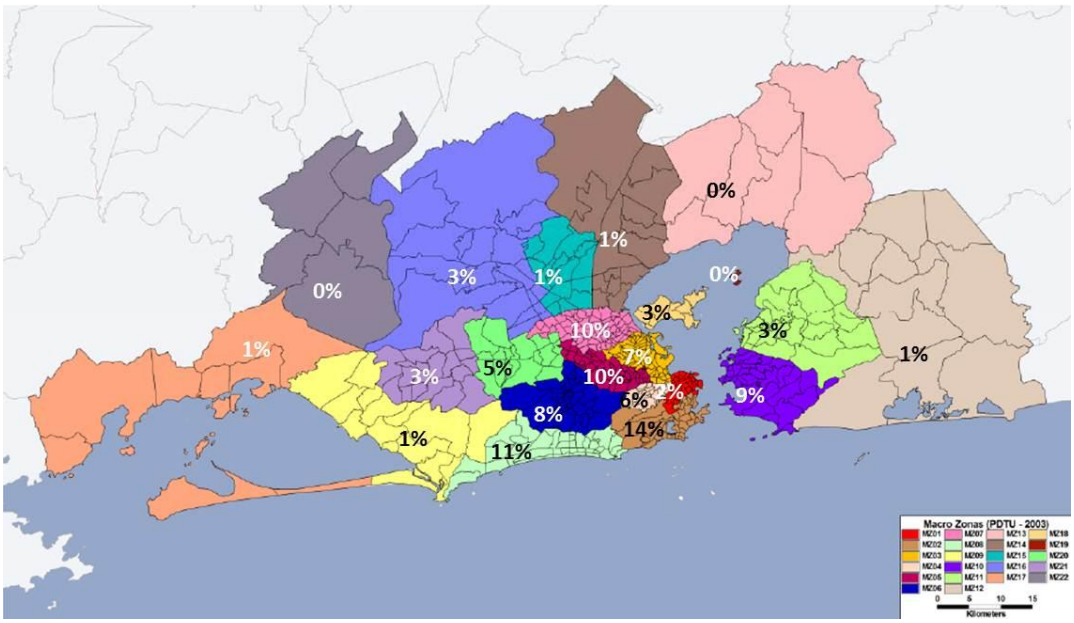

Figure 19 – Spatial Distribution of Population above 10 Minimum Salary

A final assumption was based in previous big events held in Rio (football games and rock shows). The assumption is that 17% of spectators will reach the venues using: bicycle, car and taxi (even if the walking distance happens to be as 2 kilometers far from the venue). For the daily Olympic demand it was applied a reduction factor of 0,83.

Simulations in the Public Transport Network

The departure and arrival profiles, calculated per time frame and venue/precinct, made it possible to identify the critical days with respect to the Games' demand and that of the city. This evaluation prioritized those that would exert the greatest impact on Rio de Janeiro's entire public transport system, where there is an overlap of the flow from major corridors, from several clusters and a high background demand. Among the days with the greatest total additional demand in the morning and afternoon peaks, were chosen some off-peak demands and those with the greatest total demand or those that have the greatest impact on another region.

The demand predictions have been used to identify the necessary interventions on the public transport system in order to deliver spectator transport services at the desired service levels (below 6,0 pax/m^2) per venue zone and individual venue. Transport modelling has incorporated these predictions and the city background demand to test the effectiveness of the enhanced system. Indicative results are presented below.

Table 1 – Demand of Spectators on the 3rd day 18:00h (Olympics),
Maximum Arrival Afternoon Peak

DAY 3 18:00 - 19:00	Arrival	Departure
Maracanã	6,048	5,184
Rio Olympic Park	35,810	13,845
Riocentro	9,608	4,906
Copacabana Stadium	864	864
Deodoro Zone	2,500	0
Marina da Glória	0	3,998
TOTAL (83,627)	**54,830**	**28,797**

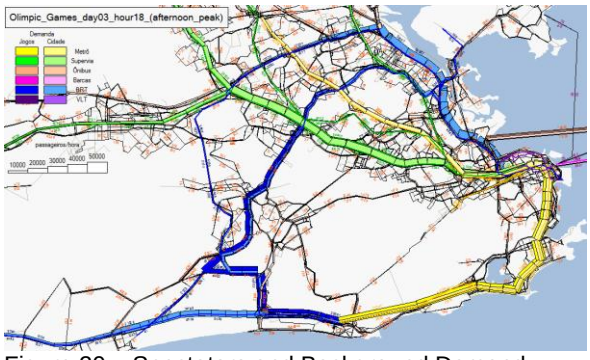

Figure 20 – Spectators and Background Demand on the 3rd day 18:00h during Olympics

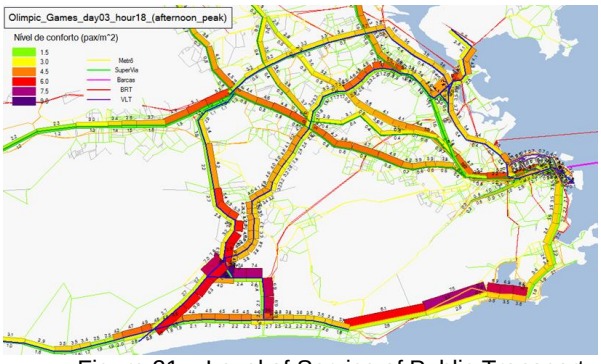

Figure 21 – Level of Service of Public Transport on the 3rd day 18:00h during Olympics

Table 2 – Demand of Spectators on the 5th day 18:00h (Olympics),
Maximum Arrival and Departure at Barra Cluster Afternoon Peak

DAY 5 18:00 - 19:00	Arrival	Departure
Maracanã	6,048	5,184
Rio Olympic Park	34,802	15,055
Riocentro	10,490	6,922
Copacabana Stadium	864	864
Marina da Glória	0	3,998
Sambódromo	0	756
TOTAL (84,983)	**52,204**	**32,779**

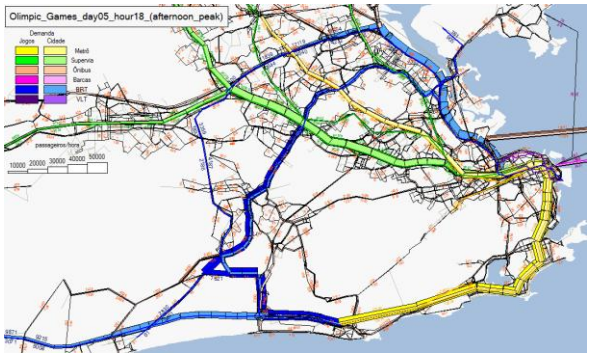

Figure 21 – Spectators and Background Demand on the 5th day 18:00h during Olympics

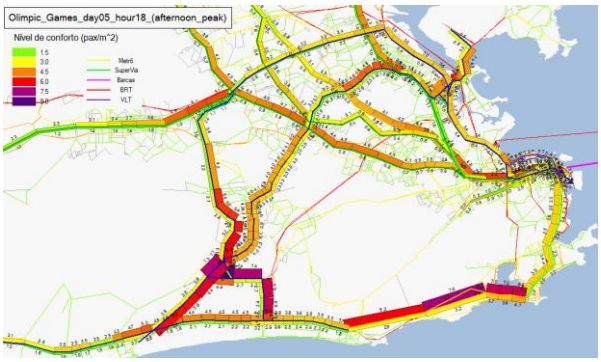

Figure 22 – Level of Service of Public Transport on the 5th day 18:00h during Olympics

Table 3 – Demand of Spectators (Paralympics)

DAY 5 8:00 - 9:00	Arrival	Departure
Maracanã	19,320	
Rio Olympic Park	11,711	
Deodoro	2,422	
Copacabana stadium	700	
Marina da Glória	0	
Sambódromo	0	
TOTAL (34,153)	**34,153**	

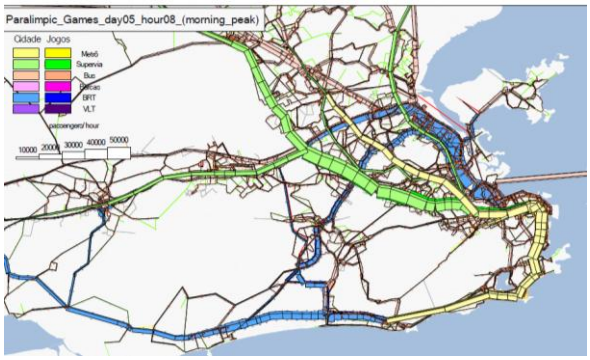

Figure 23 – Spectators and Background Demand on the 5th day 08:00h during Paralympics

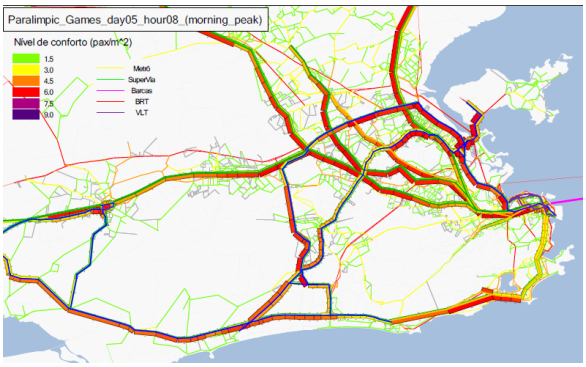

Figure 24 – Level of Service of Public Transport on the 5th day 08:00h during Paralympics

The demand reduction due to school holydays is quite the same size of the games additional demand in the busiest events. Overall, there are very few moments along the 17 days where the games demand surpasses the relief proportioned by this strategy. Although this happens only in the morning and afternoon peak hours, there is a clear benefit to users in the creation of special express services linking rail stations Madureira, Vicente de Carvalho and Jardim

Oceânico to Olympic Park and Riocentro all day long. Along the BRTs, it is where the Games demand exceeds the demand relieve due to school holidays. The express services will be operated by the regular BRT fleet that will be relocated from other lines and corridors.

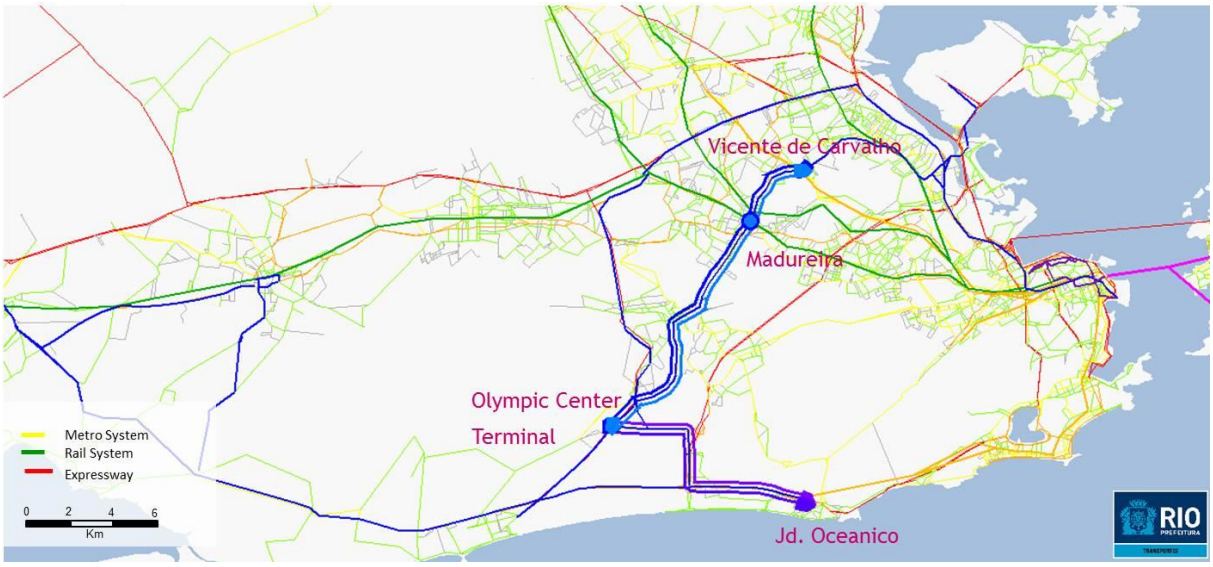

Figure 17 – Express BRT Services to Barra Zone

The off-peak hours in several venues, where there is demand is above the regular supply for that period of the day, will demand that trunk operation is kept higher for these hours with no charge to the systems.

The schedule and places of the events are really harmonious with the background demand of the transport in Rio. The heaviest coincidence of events happen off-peak and in the weekends; the most popular events in Barra and Deodoro cluster during morning and afternoon peak hours attract audience in the morning and carries people back to their homes and hotels at night, mostly in the counter-flow.

CONCLUSIONS AND FINAL COMMENTS

The Olympic and Paralympic Games represent an immense opportunity for Rio improve its public transport system, providing accessibility not only during the games but for its inhabitants for the years to come. It must be stressed that the results presented here are a picture taken three and a half years before this great event. The decisions about the construction of new infrastructure and venues are, evidently, already taken, but on the way to the games, many studies may still be done that could point to other measures aiming to improve the performance of the transport system. If deemed necessary, for instance, travel demand management strategies could be proposed, as:

- Provision of incentives for simultaneous holidays in the public administration

- Implementation of rolling shift patterns for public administration

- Expansion of the current freight delivery restrictions in terms of time and area

Communication and advice-based initiatives for travel demand, as been seen in the London Games, are a central part of these strategies.

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